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An Economic Analysis of Demand and Supply for Irrigation Water in Utah: A Linear Programming Approach

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AN ECONOMIC ANALYSIS OF DEMAND AND SUPPLY

FOR IRRIGATION WATER IN UTAH:

A LINEAR PROGRAMMING

APPROACH

by

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Mark Holland Anderson

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by

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Water provides the lifeblood of Utah's agricultural economy. It is the subject of much controversy and litigation and yet most opinions on the subject are based on opinions and prejudice rather than upon the basis of sound scientific examination. This paper attempts to provide some of the economic information necessary for sound decisions in the development and use of Utah's water resources with respect to agriculture.

Utah has been divided into ten drainage regions (hydrologic subregions) and the presently irrigated and potentially irrigable land according to land class was estimated for each county or portion of a county within each of the regions. Water use factors, crop rotation constraints, costs of production, yields, product prices, and costs of bringing new land into production were also estimated. These values were then used in the linear program demand model to estimate a normalized demand (marginal value product) curve for water to be used in agricultural production within each region. The available level of

water was varied in each of the demand curves to estimate the relationship between the quantity of water and its economic value (a demand function).

Within region supply (marginal cost) curves for water to be used in agricultural production were estimated for the years 1965, 1980, and 2000 using a linear programming (L.P.) model. The demand and supply curves for each region were combined to estimate an equilibrium point (marginal value product = marginal cost) for each of the three time periods in each region.

Potential development within each region is also discussed. Demand curves for water to be used on potentially irrigable land were estimated with various underlying assumptions. The marginal water values identified in this manner were compared to the average cost of importing water into each region and with the marginal cost of using any excess water found within the region to open new agricultural areas.

The general conclusions from the study indicate that most parts of the state suffer from a water shortage in that more production could be obtained from the presently irrigated land through the use of more water and/or the transfer of water from lands with low productivity to higher quality land. There are, however, many cases of water waste. The model is not designed to adequately evaluate the economic feasibility of water importation projects but those regions with the greatest potential for development are identified. The models indicate that, given the present cost and price structure, agriculture alone probably could not economically justify most water importation schemes at this time.

(156 pages)

INTRODUCTION

Nature of the problem

An "adequate" supply of water is essential for the economic well-being of an area. Utah is a semi-arid region in which little water is naturally available at the right time or in the right place for beneficial use. Much of the precipitation occurs in the mountainous, sparsely-populated areas. Some of these areas receive up to 60 inches of precipitation, mostly during the winter months, while many of the agricultural and industrial areas, where the water can be used, only receive about 10 inches per year. This means that most of the water used in the state must be transferred in time (from wet to dry season) and in space for beneficial agricultural and urban uses (King, 1972). The area could be described as being "a great plateau crossed by lofty mountain ranges". Some of these mountains are over 13,000 feet high and the average elevation of the state is 6,000 feet above sea level. Approximately 70 percent of the land in Utah is owned by the federal government. The Great Basin, the heart of the state, is one of the driest areas in the nation. Utah is partially cut off from moisture-bearing winds because it lies between the high ranges of the Sierra Nevada and the Rocky Mountains. The development and efficient use of water in Utah is very difficult and costly, due to the wide geographic and cyclic variations of precipitation and erratic seasonal distribution. For more detailed information on the state, see King (1972).

Generally, Utah is considered to be an area of chronic water shortage. It has been estimated that nearly two-thirds of the state's approximately 1,408,600 acres of irrigated land have access to only partial supplies of water and that supplemental irrigation on those lands could significantly increase yields. It has also been estimated that the state has over 2 million acres of swamps, marshes, mud flats, and valley bottoms suffering from an excess of water. In fact, more water is evaporated from streams and ponds and used in transpiration by water-loving weeds, trees, and shrubs than is withdrawn for public supplies. In addition, a major share (69 percent) of Utah's allotment of the Colorado River water continues to flow, unused, out of the state. Even with the addition of currently authorized developments, Utah will only be using a little over half of her share of the Colorado River waters (Utah Water and Power Board, 1963, p. VII).

Today, between three and five percent of Utah's total land area (84,916 square miles) is irrigated. This small amount of land, however, provides almost all of the crops produced in the state. There are approximately 1,408,600 acres of land which are presently irrigated and approximately 5,528,100 more acres which are of sufficient quality that they could be converted to irrigated production if adequate supplies of high quality, relatively inexpensive water were available at the right place and time. This assumes, of course, that the market for agricultural products is such that it can successfully absorb the increased output from these new lands without a severe effect on prices. Production on many farms could shift to more intensive, more profitable crops if supplemental irrigation water were available.

(Pacific Southwest Interagency Committee, 1971 b, 1971 c, 1971 e, 1971 f; Pugh, 1971; Shafer, 1971) [Hereafter, the Pacific Southwest Interagency Committee will be referred to as PSIAC.] This is not to say that it would be economically feasible to provide this supplemental irrigation and/or bring some portion of the potentially irrigable land into production, but only that this possibility does exist and that the necessary supplies of water are available.

One major problem that relates to potential water resource development is that, for the most part, the major water supplies are geographically removed from the areas which contain the potentially most productive lands. For example, the arable lands are mainly found in the Great Basin portion of the state, which is separated from the major water supply, the Colorado River, by a 3,000 foot mountain barrier. It will require much planning to unite these land and water resources in the most economical manner, or even to determine if such a union is economically justified. The water deficiencies of Utah do not really imply that insufficient supplies of water are available. Instead, they relate to the state's ability to treat, store, transport, and distribute the supply that is available. In short, the problem is a seasonal and geographical maldistribution of water supplies. There are many physical, legal, social, and financial problems associated with the development and management of Utah's water resources. Proper planning and investigation of these problems, and isolation and evaluation of the possible solutions are essential (Utah Water and Power Board, 1963, p. VIII).

Technological advancements in recent years have made large-scale water transfers technically, if not economically feasible. As a result of this, many large-scale projects are being planned and some are being constructed. If water resources are to be allocated in society's best interest, alternative sources of supply, competitive and complementary uses and regions, timing and sequence of development, and external factors must be considered, as well as determination of the quantity of water to be supplied. In the past, most water resource developments have been planned one project at a time, with little concern for the overall demand for water in the state or region. Many of these decisions have been based on local self-interest, dollar trading, or short-run considerations. Because of this, many of the important factors have been given too little consideration. According to Thomas C. Anderson:

> Development and allocation of water calls for a long sequence of crucial decisions. Heavy capital investment insures that once a project is constructed, it is virtually permanent. Erroneous judgment results from consideration of only limited points of view or of only part of a problem. This is often inadequate and could result in significant long-term misallocations of society's resources. (Anderson, 1972, p. 1)

In 1847, under the direction of Brigham Young, streams in Salt Lake City were turned from their original channels into canals and ditches and then into furrows. From that time on, the life of much of Utah has depended upon her rivers. Without these river waters which have been diverted for irrigation use, thousands of acres of excellent farm land would still be desert. Most of the land which is now tilled in Utah would be nearly worthless without some way to irrigate it. The use of water in agriculture in the arid parts of Utah is a good example of water as a critical production constraint. Crop yields are much higher when water is applied to the land and agricultural enterprises are more intensified.

From the very humble beginning in 1847, Utah's agriculture has grown into a major industry. In 1969, the gross annual income in Utah from the state's agricultural output was approximately $225,000,000 (U.S. Dept. of Agriculture, Agricultural Statistics, 1970, p. 475). When the multiplier effect is also considered, the true importance of irrigated agriculture to Utah's economy becomes very clear. Bradley, Short, and Kolb (1970) estimated the Type I income multiplier for agriculture to be 2.05 (the sum of the direct and indirect household payments, divided by the direct household payments) while the Type II income multiplier for Utah's agricultural industry (the sum of the direct, indirect, and induced income payments divided by the direct income payments) was estimated to be 3.18. This means that for every $1.00 of final demands for agricultural products, between $2.05 and $3.18 of additional income is generated in the state.

There have been many shifts occurring in Utah's economy in recent years. Proportional increases in population, labor force, and employment have been greater in Utah than the national average. From 1940 to 1964, the U.S. population increased by 45 percent, while the national labor force increased by 50 percent and employment rose by 60 percent. During this same period, Utah's population increased by 81 percent, the labor force in Utah had a 100 percent growth rate, and employment increased by 130 percent within the state (Nelson and Harline, 1964). It is expected that the future average population growth in the Great Basin region, which comprises the western part of

Utah and holds the majority of her million plus citizens, will probably be 2.5 percent per year (U.S. Water Resources Council, 1968). The greatest economic development and concentration of people in Utah is found along the Wasatch Front--(Provo, Salt Lake City, Ogden, Logan), which is a relatively small region on the eastern edge of the Great Basin. Projections of the future suggest that there will be a continuing shift toward this region in urban, commercial, and industrial activities. It is also possible that other areas which have shown little urban growth in the past may experience such growth because of government policies to curb urban congestion, technological advancements in oil shale development, electrical power generation projects, etc. (King, 1972). As this development progresses, the demand for water, especially for municipal and industrial (M & I) uses, will increase. This will occur even if no new lands are opened to cultivation and irrigation in the future. It is essential that means be devised to anticipate these future demands and that alternative ways of meeting these demands be analyzed if an optimal allocation of water and water-related resources is to be achieved.

The position of water as a resource in Utah was articulated by B. Delworth Gardner, Head of the Economics Department at Utah State University:

> Judged by almost any criterion, but especially in terms of human welfare, water is a crucial commodity in Utah. It is "consumed" in a variety of ways by individual households. It is used as a productive input by many kinds of business enterprises. It limits types and areas of agricultural production, and it is an indispensable ingredient in almost every outdoor recreational activity. These and other demands for water are rising sharply and thus water is becoming increasingly scarce. The productivity of Utah's economy and the aesthetic quality of life within her borders

> will be determined to a great extent by how wisely water resources are conserved, developed, and allocated. This requires thoughtful, progressive planning. (Gardner, 1966, p. 2)

It is clear that economic returns to Utah from water and water-related resources can be improved through proper analysis of resource allocation alternatives and through the implementation of improved resource policies. This can be done by considering not just one project but by considering the various means of meeting this demand. Supply and demand models have been developed for each of the ten hydrologic subregions in the state. The "method of procedure" section of this report will contain more information concerning these models. Water as a resource falls into three main use categories: agricultural, municipal and industrial, and recreation and maintenance of natural vegetation and wildlife. In Utah, agriculture uses many times more water than M & I uses and irrigation will undoubtedly maintain its position as the largest water user in the state (King, 1972). This report will examine the supply of and demand for irrigation water in each of the hydrologic subregions. By manipulating the above-mentioned supply and demand models, a demand curve will be derived for water on potentially-irrigable acreages with varying underlying assumptions. This study will enable those responsible for planning for the future needs for water in Utah to base their decisions on a more sound economic foundation.

Objectives

1. To develop demand functions for irrigation water in each of the ten hydrologic subregions in Utah. Separate demand curves are to be developed for water to be used on presently-irrigated land and that to be used on potentially irrigable acreages.
2. To separately combine the above demand curves and previously developed supply curves in each hydrologic subregion.
    a. To isolate policy alternatives which might be indicated by the results.
    b. To examine the possibility of opening up new areas for irrigation. Approximately 13 percent of the total land area of Utah is arable. Most of this land is yet to be developed.
    c. To determine the optimal allocation of the water resources in agriculture within each region.
    d. To examine the economic efficiency of present water use in each region by comparing the results of the model with available figures showing actual water use. Areas and uses where significantly more than or less than optimal water use is occurring may be detected.
3. To provide information on water resource allocation to be used by those responsible for water resources planning in Utah, including such groups as the Bureau of Reclamation, Soil Conservation Service, the Utah Department of Natural Resources, the Four Corners Commission, etc. This would

help define the State Water Plan by evaluating the economic impact of water resources development in Utah or the lack of such development. The Utah Water and Power Board Act of 1947 declares that water is the "property of the public", therefore, the public can manage the water so that "it can be put to the highest use for public benefit". (Gardner, 1966) Since the state has the legal obligation to control the water resources of Utah, it is essential that state officials have at their disposal information which will guide them in making sound economic decisions.

4. To help develop a general planning methodology for the allocation of water resources in the several water-use sectors in different areas. In other words, to develop a methodology which is also applicable to areas outside of Utah.

THEORETICAL DISCUSSION AND METHOD OF PROCEDURE

The study unit

The geographic unit which is most commonly used for water resources planning and development is the river basin, or a closely related group of basins which drain to a common point. The visible and invisible water supplies are connected and continuous within such a hydrologic complex. There are three such major drainage basins in Utah, the Colorado River Basin, the Great Basin, and a very small portion of the Columbia River Basin. Within each of these drainage basins, many streams and stream systems make up smaller hydrologic areas which are especially suited for analysis as individual units. These smaller hydrologic units will be referred to as "hydrologic regions" or "hydrologic subregions" in this report (King, 1972).

The state of Utah has been divided into ten hydrologic subregions (Wilson, Hutchings, and Shafer, 1968; Utah Water and Power Board, 1963). The studies conducted by PSIAC divide Utah in three areas, the Great Basin Region, the Upper Colorado Region, and the Lower Colorado Region. The area which is defined as Region 9 in the publication by Wilson, Hutchings, and Shafer and in the Utah Water and Power Board report lies in both the Upper and Lower Colorado Regions in the PSIAC reports. Since the PSIAC information is a major source in this study, Region 9 was divided into two parts. The part which is in the Upper Colorado Region is listed as Area 9 in this study, while Region 10 is that part which is included in the Lower Colorado Drainage

Area. The tenth region in the Wilson, Hutchings, and Shafer work, the "Columbia" Region, is excluded from this model because it covers a very insignificant portion of the state and has very little arable land and few prospects for the development of irrigated agriculture. The hydrologic regions and their numbers are as follows:

Hydrologic Subregion	Area Explanation
1	Great Salt Lake Desert
2	Bear River
3	Weber River
4	Jordan River
5	Sevier River
6	Cedar-Beaver
7	Uintah Basin
8	West Colorado
9	South and East Colorado
10	Lower Colorado

See the map in Figure 1 for a visual presentation of these hydrologic regions.

Economic efficiency in water use

It has been argued that if the water supply regions are reasonably self-contained hydrologically, and if inter-basin water transfers are costly and therefore unlikely, then, under these conditions, optimal water allocation in the hydrologic subregions of the state will coincide with optimal state allocation (Gardner, 1966). The costs

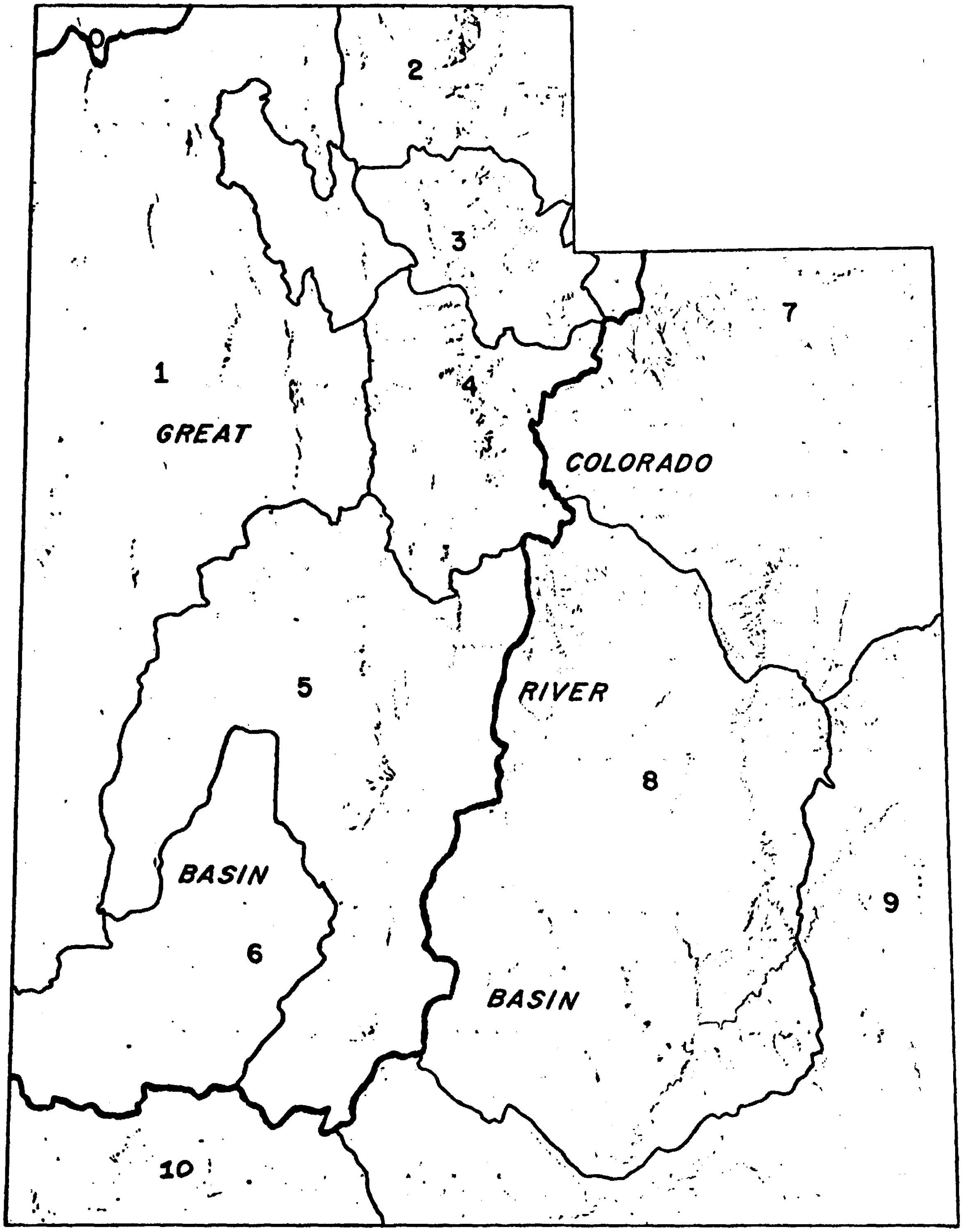

Figure 1. Hydrologic study areas of Utah

of inter-basin transfers of water are expensive (King, 1972) and, by definition, the ten hydrologic subregions are hydrologically self-contained. Therefore, by using a linear programming model to determine the optimal level of water use in each region, the approximate optimal use for the state can be defined.

Since water is regarded as a scarce resource, it is assumed that the goal of society is, given certain constraints such as water quality, income distribution, etc., to allocate water in an "efficient" manner. One definition of economic efficiency, relating to water use in Utah, has been proposed by Gardner:

> Economically efficient water allocation within a state, therefore, could be defined as the allocation that results in maximization of state per capita income. This concept must not be confused with technical efficiency in water use, where each water user must employ the best practices to prevent waste. Economical efficiency, of course, assures a high level of technical efficiency. (Gardner, 1966, p. 9)

In the same publication, Gardner also points out that, in some cases, aggregate state income rather than per capita income may be the best indicator of welfare. The goal of economic efficiency is to maximize human welfare. With this idea in mind, it becomes obvious that if, within a given area, a resource such as water could be allocated in a manner which would increase production and income in the area, the new allocation would be more efficient.

Efficiency in water allocation is achieved when water is allocated between alternative users and uses in such a way as to maximize the total production of goods and services. If water were the most constraining input in agricultural production, as it is in many areas, then optimum allocation would occur when the returns to water itself were maximized. This condition (maximum returns to water) would exist when the marginal productivities of water were equal for every agricultural use and user in the water supply area (hydrologic subregion in this case). If this condition was not met, increases in total water productivity could be achieved by transferring some of the water resource from agricultural uses or areas of lower marginal productivity to those of higher productivity. The linear programming model which is used in this study is an optimizing model. It is designed to maximize the objective function, which is the net return to water.

The principal of diminishing returns, when applied to water use, simply states that the marginal product of water, holding other inputs constant, declines as more water is applied. This holds true both for an individual farm and for a given farming area. This being the case, if the farmers in one area have significantly more water per acre (all other factors being equal), an additional unit of water would have more value in the area of scarcity than in the area of plenty. An economic efficiency model, such as the Linear Programming model, (L.P. model) would be especially appropriate in the agricultural sector because optimal allocation would require equality of marginal products among agricultural users and uses, and this requirement is easily met by an optimizing linear programming model.

Estimating water demand with linear programming

If "maximum water value" is used as the water efficiency criterion, then a demand curve for all uses and users of water is required for optimal planning decisions. Such a curve is a schedule of prices that show what a person is willing to pay for various quantities of water utilized over a given period of time. Such information as is contained in a demand curve is prerequisite to the achievement of economic efficiency under the criterion of maximizing the value of water. In this study, linear programming models will be used to estimate the supply and demand curves for water in each of the ten hydrologic subregions. The purpose of this is to determine the schedule of values of water (marginal value product, or derived demand) as a productive input in Utah's agricultural industry.

Linear programming has often been used to estimate a demand function for water. Hartman and Wittlesey (1960), Moore and Hedges (1963), Miller, Boersma, and Castle (1965), Johnson (1966), Stults (1966), McGuire and Brown (1967), Gisser (1970), Anderson (1972), Hiskey (1972), and others have used linear programming and other techniques to estimate demand functions for water. For a more complete analysis of the many applications of the linear programming model to solve water resources problems, see King (1972) and Hiskey (1972).

The demand for irrigation water is derived from the demand for the crops produced. Irrigation water has value only because the crops produced by the water have value. The L.P. model which is used to determine the demand curve for irrigation water included 8 crop activities: alfalfa hay with a full, and with a partial supply of water, barley, nurse crop (a combination of barley and alfalfa), corn silage, sugar beets, irrigated pasture, and dry-land wheat. Even though livestock production accounts for much of the agricultural output of the state, no livestock enterprises are included in the model. Irrigation has value in producing crops. The demand for these crops may be derived from the value of their contribution to livestock output. This being the case, the relevant value to use in determining the demand curve for irrigation water is the marginal value product of the crops which are directly produced by water in connection with the use of other resources. The marginal value product or demand curve is also determined by the production functions of the various crops, the price of the crops, and the price of other inputs such as land, labor, fertilizer, and capital. These production functions depend upon the climatic conditions of the area, the soil quality, the farming methods, and level of technology used. Given these and other factors, it is possible to estimate such a production function relating output and water use on each of the several crops. These production functions, together with the prices of the inputs and outputs, will determine a value of net product or response function. This production function analysis is one way to determine the marginal products of water used in agriculture. The net marginal value product is the first derivative or slope of the net value of total product curve. The marginal productivity functions that are derived in this manner are readily converted into water demand curves by multiplying the marginal productivity functions by the prices of the agricultural commodities (hay, barley, etc.) which are produced with the water, or by multiplying the total productivity function by the price and taking the derivative. The marginal revenue curve or, as in this case, the marginal value product curve, is, by definition, the demand curve (Henderson and Quandt, 1958).

Linear programming has been defined as: "...a technique for solving maximization and minimization problems confronting decision-making agencies subject to certain side conditions or constraints which limit what the agencies are able to do." It is the simplest of the mathematical programming techniques and, because of the development of modern electronic computers, it is the most widely used. (Leftwich, 1966)

There are several basic assumptions which underly the linear programming technique. There are always constraints or limitations on the decision-making agency. This includes such things as constraints on land use, rotation schedules, etc. Input and output prices are assumed to remain constant. This means that the farmers in each hydrologic subregion have no control over prices. Finally, input-output, output-output, and input-input relationships are presumed to be linear. (Leftwich, 1966) For the purpose of this study, it is assumed that there are no cost outlay or labor constraints. Thus, it is assumed that adequate amounts of labor or cash are available to pursue the most costly or labor intensive crop rotation. Therefore, the only constraining inputs in the derivation of the demand curve are the land, according to land class and county, and the irrigation water as the amounts of it are parametrically reduced to derive a demand curve. Of course, there are many non-input constraints in the demand portion of the models in the form of such things as rotation constraints, yield levels, etc., which impose costs and limit profits. The models which are used in this study involve multiple inputs and multiple outputs.

The critical assumptions underlying the model are:

1. A firm water-right is assumed to exist. This means that the demand for water on presently-irrigated land must be met before water within a region can be released for new development.
2. It is assumed, for the purpose of deriving the demand curves, that an unlimited amount of water is available in each region. The supply schedule provided by the model will, when interacting with the demand schedule, constrain the amount of water which actually should be applied.
3. The process of agricultural production can be divided into separate, independent activities.
4. Fractions of these production activities can be used.
5. Constant returns to scale and fixed proportions among inputs characterize each of these activities.
6. Projected demands for water to be used in municipal and industrial activities must be met in the supply portion of the model before water will be released for agricultural uses.
7. No external economies or diseconomies exist in the model.
8. The level of farm managerial ability is slightly above the present average to reflect 1980 conditions. This assumption is reflected in the yields.
9. Yields for each land class are assumed to be constant

within each county in each hydrologic subregion.

10. Linear demand curve relationships are assumed to exist.

Graphical example of the linear programming process

A simple graphical example of the linear programming process may help clarify the manner in which a linear programming problem can be used to develop a complete demand curve. Two crops, barley and corn, will be used in this example problem. Let us assume that the person has two "fixed" resources which prove to be constraining. That is, all but two of his resources are available in sufficient amounts so that all of the land could be planted into the crop that used the greatest amount of that resource. The two constraining resources are land and current expense capital. Let us assume that the farmer has 100 acres of class II land and $2,000 at his disposal. The corn silage yield is twenty tons per acre and the yield per acre for barley is 75 bushels. The capital expense requirement on corn is $40.00 per acre and that for barley is $10.00. In Figure 2, if all the land were devoted to the production of corn silage, 2,000 tons could be produced while 7,500 bushels of barley could be produced if all of the land were devoted to barley production. Iso-resource line a-b in Figure 2 depicts this situation. If all of the capital were used in the production of corn, 1,000 tons of silage could be produced while 15,000 bushels of barley could be produced with the same amount of money. This situation is shown by iso-resource line c-d in Figure 2. The shaded area, which is bounded by the line a-e-d in the figure, is the area of feasible solutions because it is only within that area, where

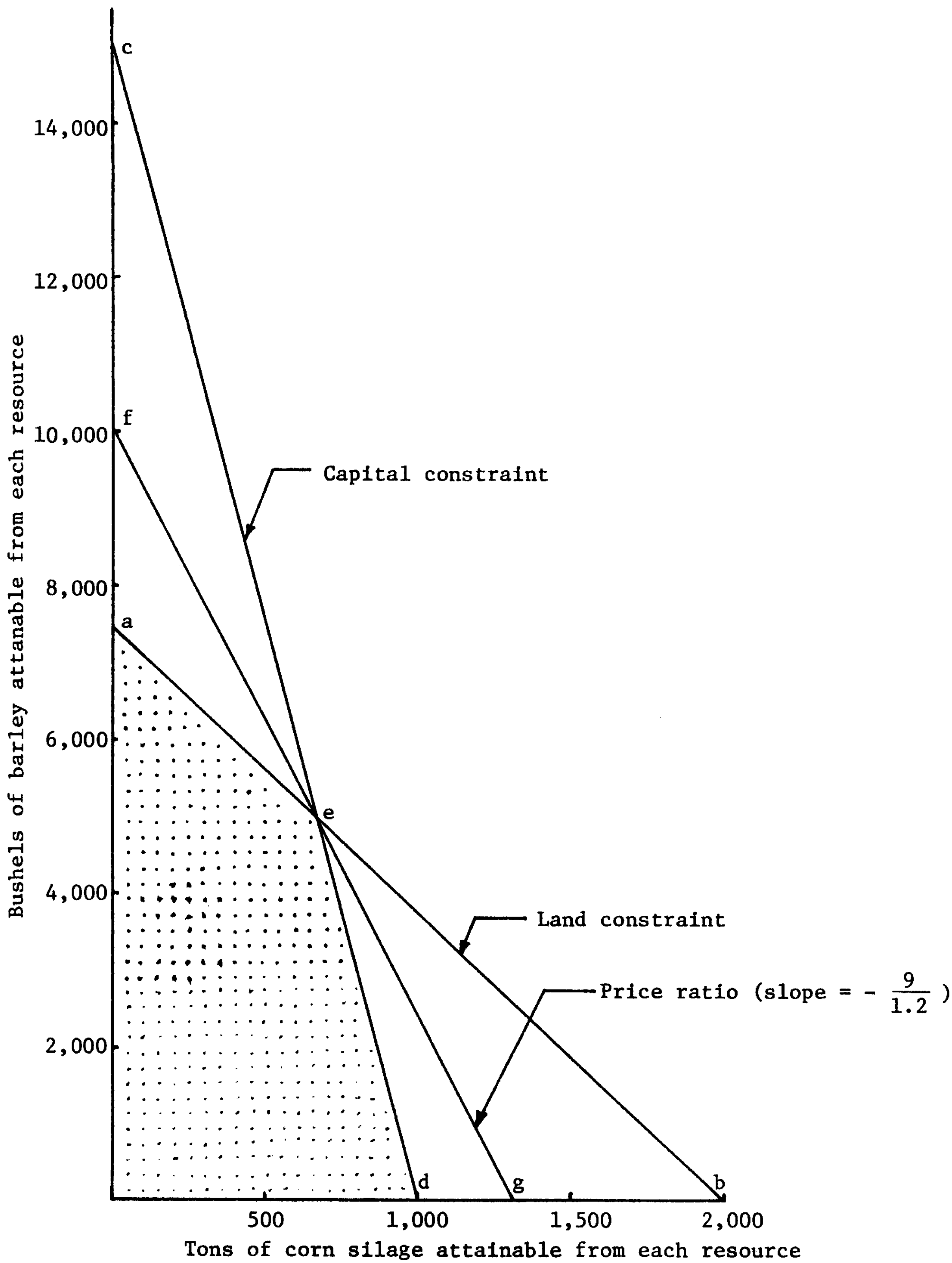

Figure 2. Graphical representation of example linear programming problem

there is both adequate land and capital, that production can occur. Points on the resource lines which lie above point e denote enterprise combinations which are not attainable because another resource is limitational.

The problem now is to find the optimum production program. This optimum level is defined in the conventional manner of product substitution rates (the slopes of the two segments of the opportunity curve a-e-d) in relation to the price ratios. Linear programming does this by determining all of the production possibility curves and by applying the product price ratio to these possibility curves.

Let us assume that corn silage is selling for a price of \$9.00 per ton and barley can be sold for \$1.20 per bushel. The optimum production program can now be identified by finding the point where the price ratio line f-g is exactly tangent to the production possibilities curve, a-e-d. In Figure 2, one can see that the optimum production point is at point e and that 666.6 tons of corn silage and 5000.25 bushels of barley will be produced. Corn acreage would be 33.33 while 66.67 acres would be planted into barley. Algebraically, this problem could be stated as:

Maximize: $Z \qquad Z = 1.2X + 9Y$

Subject to:

$$X + Y \leq 100$$

$$10X + 40Y \leq 2000$$

$$X \geq 0$$

and $Y \geq 0$

where Z = Total revenue

X = Barley acreage

Y = Corn acreage

For a more complete analysis of the linear programming process, see Heady (1954) and Leftwich (1966, pp. 341-362).

The demand model

The models which are used in this study to estimate the demand curves for irrigation water in each of the regions are much more complicated than the above example. However, the logic is very much the same. The basic model, in matrix form, which is used in this study is as follows:

$$\text{Maximize:} \qquad P = C\,X$$

$$\text{Subject to:} \qquad A\,X \leq b$$

$$X \geq 0$$

Simply stated, these equations refer to the fact that the demand portions of the models are designed to maximize the net benefit, subject to the costs associated with production. As has already been explained, in solving the primal problem, the model determines the optimal combination of resources, subject to certain constraints, that will lead to the greatest net benefit (where revenues exceed costs by the greatest possible amount).

Every linear programming problem has a primal problem and a counterpart problem called its dual. If the primal problem was to maximize output with a given cost outlay, the dual would be to minimize the costs for the given product output. In the dual problem, the goal is to impute minimum values or shadow prices to the fixed facilities which are just sufficient to absorb the total rent. In this study, the dual of the demand models is to determine the shadow price or marginal value product of water as a productive input in irrigated farming. The objective equation of the dual problem can be stated thus: $v_m + v_n + v_r = V$. In this equation, v_m, v_n, and v_r refer to the value to be imputed to fixed factors m, n, and r, respectively, while V represents the total valuation to the fixed facilities. The values assigned to each fixed factor must be such that a dollar's worth of the productive element used in producing the output must yield a dollar in rent. The shadow price is the marginal value product (price times marginal physical product). It will be noted that the dual solution and the solution to the primal problem provide the same information for the minimum values that can be imputed to the fixed production facilities. The minimum values (from the dual solution) total to an amount equal to the maximum rent they can produce (the primal solution). (Leftwich, 1966) The shadow price of water is defined as, "The price which would arise if a market were established in which all individuals demanding and supplying water could be represented." This, of course, is an ideal situation which rarely exists in the "real world", but it is a useful analytical tool and will be used frequently in this report. The returns to water would be at a maximum when the marginal productivities or shadow prices of water were equal for every use or user in the water supply area. If this assumption were not met, then increases in total productivity due to water could be achieved by transferring some of the water from uses of low marginal productivity to uses of higher marginal productivity. This analysis, of course, assumes that water is the main constraining resource on production, as is true in most of Utah. The dual solution allocates the rent, or marginal value product, to the fixed factors. In this case, the resource with which the study is concerned is irrigation water.

Assuming that the assumptions underlying the model fairly accurately reflect the conditions of the real world, the technique can be used for planning purposes in defining the final optimum allocation of the resource under consideration. The linear programming technique does this by generating the implied marginal products (shadow prices) of the allocated resources in alternative activities.

A complete demand (marginal value product) curve was derived by having the linear programming model determine the optimal allocation of resources assuming that all of the land on which revenue exceeds costs can be used and that an unlimited supply of water was available so the model can use the level of water and rotation combinations that maximize the net return. The dual solution revealed the quantity of water that was used and the shadow price of that water. The remainder of the demand curve was estimated by parametrically reducing the available water supply and having the model provide output of the level of water use and its shadow price at each basis change. As water availability was reduced, fewer acres were irrigated and, as the water became even more scarce, the rotation was changed to rotations which were less water intensive. Thus, as water availability declined, the value of irrigation water increased.

In Figure 3, the portions of the model have been separately identified to illustrate components of the model. The segments that are not found in the illustration have zero coefficients.

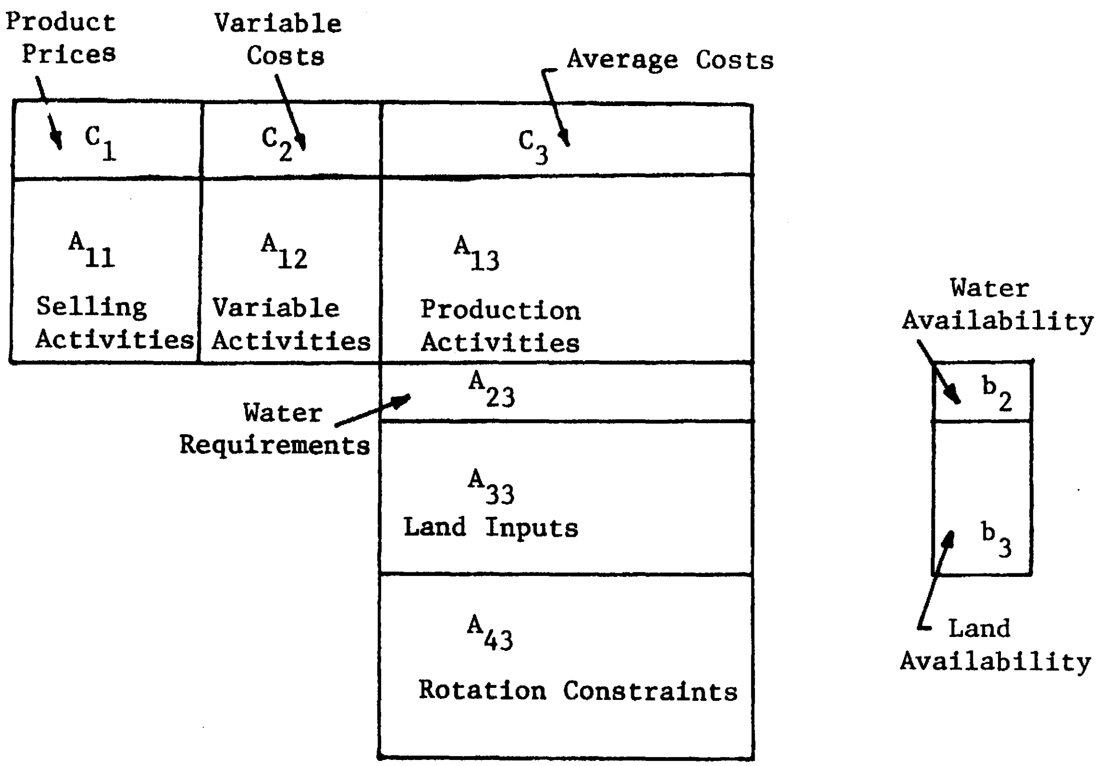

Figure 3. Diagrammatical representation of the linear programming model

Matrix A_{11} and vector C_1 represent selling activities where each unit of production is converted to its dollar value. In the model, variable costs (those costs which change as the level of output per acre of the agricultural products change) are represented by C_2, while the associated activities are represented by A_{12}. The bulk of the matrix is made up of the production activities (A_{13}). The set C_3 represents the costs which do not vary with output per acre of crop. A_{23} is a vector of water requirements for each of the various crop activities. The input of land into the crop activities is represented by A_{33}. The amount of irrigable land in each subregion is represented by b_3. The rotation constraints are represented by A_{43}. For a more complete discussion of the demand models, see Anderson (1972).

The three demand curves

Using this linear programming approach, three demand curves for water used in agricultural production have been estimated for each hydrologic subregion. The first demand curve pertains only to presently irrigated land, and was obtained by allowing water to be applied only on such land; that is, potentially irrigable land was only allowed to produce dry-land wheat. In deriving both the second and third demand curves, irrigation on presently irrigated land was excluded, so as to independently estimate marginal value product schedules (demand curves) for water on presently undeveloped land. The second run allowed the models to bring potentially irrigable land into production according to its profitability. This means that all class I land in a county would be developed before any class II land, class II would be developed before III, and class IV land would be developed last, if at all. The class IV land was often found to be unprofitable when development costs were added to the production costs. In deriving the third demand curve, potentially irrigable land was constrained so that it would be brought into production in fixed proportions according to the proportions of land in each land class in each county. If 20 percent of the potentially irrigable land in a county were class I, 30 percent class II, 20 percent class III, and 30 percent class IV, for every two acres of class I land that was brought into production, 3 acres of class II, 2 of class III, and 3 acres of class IV land would also have to be developed.

The first demand curve represents the demand for water to be used on presently irrigated land. The second and third curves represent the demand for irrigation water to be used on potentially irrigable land. These last two curves differ because of the difference in the underlying assumptions. It is assumed, in estimating the second curve, that land can be brought into production according to its productivity and profitability. This is an unrealistic assumption because it is very unlikely that the areas of class I soil will be large enough for efficient development. The land development costs which are found in the model were developed under the assumption that any agricultural development that occurred would be large-scale rather than spot development. The third curve was derived with the assumption that there were no large areas of exclusively high quality land. Instead, the underlying assumption was that the land classes were completely mixed in any one area and that if development was to take place at all, all grades and classes of land would have to be developed simultaneously and in proportional amounts. This assumption is also very unlikely. While large areas of class I land may not exist, there will probably be areas with relatively large amounts of the higher producing classes and quite small amounts of extremely poor land. These two curves are developed because it is believed that they depict the two extremes in demand for water to be used for new agricultural development. It is impossible to determine exactly how agricultural development would occur in any one region. However, in the supply and demand analysis in each region, these curves can be used to depict the extremes in demand, and policy implications may be drawn from the results. Obviously, if development appears to be economically unsound when the most optimistic demand function is used, there must be serious doubts about whether such development should be undertaken.

An analysis of marginal productivity, such as the one previously described, is one method of deriving a marginal productivity function (a derived demand curve). Such a derived demand curve is essential in defining optimal water allocation. Simply having one point on the function (i.e., the present level) is not enough. A more complete function over a much wider range of use is needed to determine what will happen to marginal productivity if the water supply is increased, as is done in this study.

The supply model

The resources which were available for this study were not sufficient to allow the development of a new supply model. Therefore, an existing model, which determined the supply functions for irrigation water in each of the ten hydrologic subregions of the state has been used (King, 1972; and Clyde, King, and Andersen, 1971). The model was established as a cost-minimizing problem with alternative methods (groundwater, surface water, etc.) of meeting a set of current and projected water requirements which vary through time. The input data are very different from those employed by the linear-programming demand models, but the underlying theory is basically the same. The supply (marginal cost) functions represent the increasing marginal costs of supplying water as successively more expensive sources of water are used to meet the increasing water requirements. Two sets of supply curves were developed, one set each for agricultural use and municipal and industrial use. Only the agricultural supply functions are of interest in this study.

The objective function in the supply portion of the models is to minimize cost, while the primal problem is one of resource allocation. The goal of the model is to devise a means whereby water may be moved in time and place to meet specified water requirements for the various water uses as cheaply as possible. The primary input is the natural flow of water. Activities of the models (one for each of the ten hydrologic subregions) associated with facilities already in existence have cost coefficients reflecting only annual operation and maintenance costs. Municipal, industrial, irrigation, and wetlands uses compete for the available water.

These models consider precipitation, natural flow, and existing developments, as well as the cost of increasing existing supplies through groundwater developments and seasonal and/or spatial water transfers.

Minimum requirements were established for wetland diversions and basin outflow. With these minimum bounds and water availabilities given, and with set levels of municipal, industrial, and irrigation diversions, the solution to the problem provides an estimate of the least cost method of supplying water. If a particular diversion is changed and the problem is again solved, the change in cost of meeting the changed requirement can be determined.

Using marginal costs, the supply shadow price is the incremental cost of supplying an additional acre-foot of water. The parametric solutions to the dual of the cost minimizing linear program estimate a supply function. By holding municipal and industrial requirements constant at various levels, a series of irrigation water supply functions can be estimated, one for each level of M & I use. Supply is also defined as being the functional relationship relating to the incremental or marginal cost of making more water available to a particular group of water users while holding other uses constant. Determining these supply functions is basically a technological problem which is solved by the application of engineering cost estimates.

One important consideration on the supply side of the model is to determine the physical and economic limits for the geographic distribution of water. Generally, water can be made available at a lower cost within its river basin or hydrologic subregion than from outside. However, interbasin water transfers may be technically possible and politically desirable in some situations. It is important, therefore, to consider these possible water transfers when determining the optimum water allocation within a basin. Such interbasin water transfers are economically desirable if the marginal value product (M V P) of the water in the area into which the water is imported is greater than the M V P in the basin where the water originated by an amount at least as great as the marginal cost of importing the water (these costs include transportation costs, water loss, etc.).

The individual supply functions for each of the hydrologic subregions include only the within-basin sources of water. However, the costs of importing water into each of the regions were also calculated. For the purposes of this study, both the within-subregion supply functions and the costs of importing water will be used in determining the optimum level of water use. In the supply functions, the local water costs become infinitely high when no more local water is available. The allocation models are subjected to constraints such as hydrologic characteristics; limits on interbasin transfers; limits on artificial ground water recharge; and municipal and industrial (M & I), irrigation, and wetland water uses in each of the ten regions. Most of the activities have upper bounds for present levels as well as estimated levels of possible development. As groundwater mining or surface storage activities increase, the costs associated with those activities also increase and the marginal cost of supplying additional water is greater.

The equations of the models reflect the interdependence of the activities. For example, only part of the water which is diverted for agricultural and M & I use is actually consumptively used. The rest of the water returns to surface water and/or groundwater supplies and may be reused.

In describing the basic supply model, Thomas C. Anderson says:

> The primal problem is one of resource allocation: how to allocate water-related resources (as represented by the activities of the model) to move water in time and place to meet specified water requirements for the different water uses as cheaply as possible. . . .
>
> . . .M & I diversions may be set at a particular level and irrigation diversions varied to determine the functional relationship between the quantity of irrigation water and its shadow price. If this were done at various levels of M & I diversions, a series of supply functions could be generated.
>
> These functional relationships can be found most readily by parametrically solving the dual (resource valuation) problem. The shadow prices assigned by solution to the dual are constant for a given basis. By parametrically varying both M & I and irrigation diversions, it is possible to determine the bases and their associated shadow prices at all possible diversion levels for both water uses. . . .(Anderson, 1972, pp. 19-20).

Municipal and industrial water diversions have been estimated at 1965 levels and parametrically increased according to projected demands. This assumes that the real area of choice lies in the agricultural sector, and refers to the fact that M & I water demands are given priority over irrigation water demands. This is proper since irrigation is by far the largest water user in the state. Depending on the region, irrigation accounts for from 77 to 99 percent of the total water used. Another reason why the area of choice would be expected to be in the agricultural sector is because water used in agricultural production usually returns less rent than most M & I uses. Therefore, the main concern lies with the bulk of the water and with that which has the lowest marginal value productivity (Andersen, 1972).

As more water is required for municipal and industrial use in the future, it can be supplied by intra-basin developments of ground and surface water, by transfers from competitive agricultural users within the basin, and by interbasin transfers. The proper method of development depends upon the demand for water in each of the competitive water uses, the cost of developing surface and groundwater sources, and the cost of transporting water. The optimal economic allocation will be at the point where the marginal value product in each use and in each area is equal to the marginal alternative cost (including the cost of transportation). In addition, due regard must be given to the externalities of water use as well as to its social value for recreation, etc. The cheapest source of supply should be used (after considering externalities) to meet the increased demand. In this study, the projected demand for M & I water is met by water supplies within each region. Therefore, all imported water would be for use in agricultural production. The supply models assume that wetlands are maintained at specified levels for recreational and wildlife uses. For more information concerning the level of recreational water use and other aspects of the supply models, see King (1972).

Three supply curves, one each for the years 1965, 1980, and 2000, have been developed for each area. Information provided by the Utah Division of Water Resources (1970) was used to estimate the municipal and industrial water demand in each region for each of the three years. In estimating the supply curves for each year, M & I diversions were held constant at the projected level for that year for each hydrologic subregion. The expansion path for M & I demand was assumed to be linear. The projected M & I levels for each of the three years in each region are summarized in Table 1. In determining a supply curve for irrigation water in the model, M & I diversions can then be varied to determine the functional relationship between the quantity of irrigation water and its shadow price (marginal cost).

These functional relationships can best be found by parametrically solving the dual (resource valuation) problem. For a given basis, the shadow prices, which are found by solving the dual, are constant. The bases and the associated shadow prices at all possible diversion levels for both water uses may be found by parametrically varying both M & I and irrigation diversions. Figure 4 is taken directly from the study prepared by King (1972), as is Figure 5. Figure 4 shows the source of the water at the various M & I and agricultural use levels. Both figures represent the situation in hydrologic subregion 9 and are typical of the other nine regions. A supply curve for irrigation water can be estimated from the second figure by holding M & I water use constant at any level and by determining the basis changes (marginal cost and quantity) for irrigation water by reading the values at the basis lines horizontally across the graph from the specific M & I level. The first of the two figures shows the source of the water within each basis.

As with the demand curves, these supply curves are only approximations of the actual costs of supplying irrigation water. The results are no more accurate than the assumptions upon which they rest. For example, if either the basin outflow or wetland requirements were increased, the infeasible region (the region beyond the outer line in Figure 5) would be shifted closer to the origin. If the reverse were

Table 1. Projected municipal and industrial water requirements in thousands of acre-feet, Utah

Region	Year		
	1965	1980	2000
1	10	13	18
2	44	108	194
3	49.7	126	227
4	302.5	517	803
5	17	21	26
6	13	19	26
7	10	50	104
8	7	16	29
9	6.8	38	79
10	1.5	3 or 4	6

Source: Utah Division of Water Resources (1970)

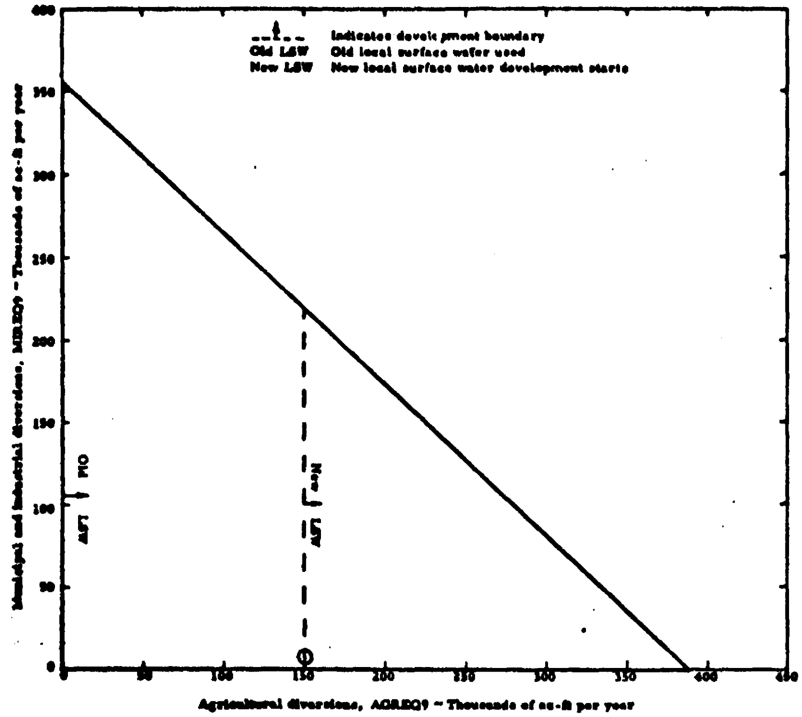

Figure 4. Supply function maps for hydrologic study unit 9 (Agricultural development map)

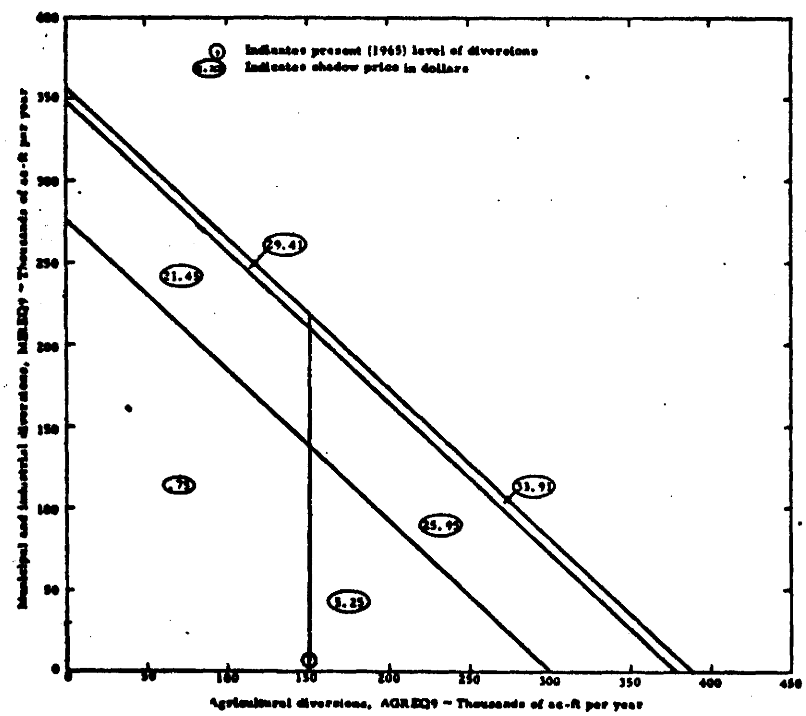

Figure 5. Supply function map for hydrologic study unit 9 (Shadow price of agricultural diversions)

to occur, the infeasible region would shift out. Altering any of the upper bounds in the model might cause one or more of the lines separating the bases to shift. Cost coefficient changes could either increase or decrease the shadow price (marginal cost) without altering the basis boundary lines.

For a more complete analysis of the basis supply model, see King (1972); Clyde, King, and Andersen (1971); Anderson (1972); and Andersen (1972).

Combining the demand and supply models

In a purely competitive market, marginal analysis shows that the profit maximization point for a firm (or, in this study, for a region) in the short run is the output level where marginal value product is equal to the marginal factor cost (M V P = M F C). It has already been established that the series of marginal value products which correspond to various levels of water diversions, as identified by the model, represent the derived demand curve for irrigation water. That is, the demand curve is a schedule that shows the amount per unit that the farmers of a region would be willing to pay for various quantities of water. It has also been demonstrated that the schedule of marginal costs and their accompanying water quantities represent the supply curve for irrigation water in each region. That is, the marginal cost figures represent a schedule of prices and water quantities which show, at any water diversion level, the cost of supplying one additional unit of water. The supply or marginal cost function has also been defined as being the portion of the marginal cost curve which lies above its average variable cost curve.

Efficiency in water allocation has been defined, given certain constraints (i.e., the environmental considerations), as being that allocation of water resources between uses and users that maximizes the total production of goods and services within an area. Therefore, the optimum water allocation within a region can be found by finding the output level which maximizes profit or net benefit for an area. This output level is the point which is defined by the intersection of the supply and demand curves of a given area. This point defines not only the optimum level of water use but also the optimum quantity of water related resources such as reservoirs, water distribution networks, etc. Therefore, the optimum allocation of water and water related resources can be found by combining the supply and demand models of each region into a single linear programming problem.

A later section will effect just such a union of the two models. In addition to combining the within-basin supply of water with the demand for water to be used on presently irrigated land, the problem of potential agricultural development will be studied.

This analysis will have two parts. First, the water supply function will be combined with the water demand curve on presently irrigated land. (See Appendix Table 11 for the equilibrium points.) After an equilibrium water price and quantity level is determined in this manner, that portion of the within-basin water supply curve which lies to the right of the equilibrium point will be compared to the two previously described demand curves for water on potentially irrigable land. This will be done by setting the water quantity level at zero at the equilibrium point and superimposing this "residual" supply curve on the two demand curves in each region. This approach is designed to determine the feasibility of irrigation development using water from within the basin. It is assumed that the demand for irrigation water to be used on presently irrigated land must be met before water can be released for use in development. The second portion of this analysis will consist of comparing the water values, as shown on the development demand curves in each region, with the cost of importing water. (See King, 1972, for a summary of the water importation costs.) This is necessary because the only imported water contained in the within-basin supply curves is that which is presently being imported. This second step is designed to determine the economic feasibility of importing water into a region for use in agricultural development. In regions where irrigation water is presently in short supply, an analysis concerning importing water for supplemental irrigation on presently irrigated land will be undertaken.

DATA FOR EMPIRICAL WORK

Before linear programming can proceed, the input data, such as production coefficients, must be known. Determining these input values is a very time consuming and expensive empirical problem. Much time and effort was spent in isolating what was considered to be the best, most consistent information to be used as input material in the demand models. All information (yield, land acres, costs, etc.) was broken down on the basis of counties and parts of counties within each hydrologic subregion. All numbers in the demand portion of the model in each region are on a per acre basis.

Land class acreages

The potentially irrigable and presently irrigated land class acreages are revised estimates, based on information obtained primarily from PSIAC (1971 b, 1971 c, 1971 e, 1971 f), Pugh (1971), and Shafer (1971). These data were altered so that they would more closely conform with information found by the Utah Conservation Needs Committee (1970) and by Wilson, Hutchings, and Shafer (1968). The raw figures were obtained from the PSIAC reports, Pugh (1971), and Shafer (1971), because they were the only available sources that listed land class acreages for each county in the state on both presently irrigated and potentially irrigable land. However, these acreages had to be altered because climate had not been included as a factor in arriving at the land class acreages. Therefore, the climate variable was included to increase the accuracy of the model. The Utah Conservation Needs

Committee (1970) report was consulted to help make the needed changes. The land class percentage breakdown, county by county, was calculated and applied to the presently irrigated PSIAC estimates and, in altered form, to the potentially irrigable acreages. The publication by Wilson, Hutchings, and Shafer (1968) was used in some areas to help determine the amount of presently and potentially irrigable land in each region when a county was included in more than one hydrologic subregion. Climatic information, obtained from Richardson (1971) was also used in preparing the data. Wilson (1972) and Shafer (1972) spent several hours going over the land class estimates making revisions based on information from their offices. Table 2 shows these land acreage estimates.

Crop rotation constraints

"Greenbelt Studies", (Davis, Christensen, and Richards, 1972) information from the U.S. Department of Commerce (1964, 1969), and consultation with personnel from the Utah State University (USU) Plant Science Department and Extension Services were used to determine the crops to be used in the model and the rotation constraints to be applied to these crops. The crops which are included in this study are barley, corn silage, sugar beets, alfalfa hay, irrigated pasture, and dry-land wheat. Dry-land wheat is the only crop which can be grown alone, all other crops must be grown in rotation. The basic rotation constraints are as follows:

1. Alfalfa Acreage $\geq$ Barley Acreage
2. Barley Acreage $\geq$ Nurse Crop Acreage
3. Alfalfa Acreage $\leq$ 5 (Nurse Crop Acreage)

Table 2. Summary of arable land acreage by county within hydrologic subregions--Utah

		Great Salt Lake #1						Bear River #2			Weber #3			
	LAND CLASS	Tooele (East)	Tooele (West)	Box Elder	Juab	Millard	Beaver	Cache	Box Elder	Rich	Weber	Morgan	Summit	Davis
		(in thousands of acres)												
Presently Irrigated	I	.2	.1	2.8				1.1	12.5		11.4			18.0
	II	2.4	1.7	5.7	1.1	4.4		50.0	25.0		32.7	7.3		11.9
	III	6.4	4.3	9.4	1.0	.5		31.5	41.7	5.2	17.0	.9	25.1	9.2
	IV	2.3	1.5	.9	.2	.1		19.1	3.9	39.7	3.9	2.0	6.9	4.4
	>IV	.1	--	2.2	.3	--		2.3	9.9	4.1	1.0	1.8	3.7	2.5
	TOTAL	11.4	7.6	21.0	2.6	5.0	0	104.0	93.0	49.0	66.0	12.0	35.7	46.0
Potentially Irrigable	I	7.0	3.0	88.9				1.1	13.8		.5			.2
	II	100.0	80.0	175.5	46.2	66.1	19.5	50.7	27.3		3.3			4.7
	III	95.6	122.4	209.7	43.8	100.6	38.9	25.6	32.6	10.2	10.9		.3	7.6
	IV	44.2	59.8	117.9	77.4	118.3	61.6	25.6	18.3	83.8	14.3	2.0	.6	7.5
	TOTAL	246.8	265.2	592.0	167.4	285.0	120.0	103.0	92.0	94.0	29.0	2.0	.9	20.0
Total Arable	I	7.2	3.1	91.7				2.2	26.3		11.9			18.2
	II	102.4	81.7	181.2	47.3	70.5	19.5	100.7	52.3		36.0	7.3		16.6
	III	102.0	126.7	219.1	44.8	101.1	38.9	57.1	74.3	15.4	27.9	.9	25.4	16.8
	IV	46.5	61.3	118.8	77.6	118.4	61.6	44.7	22.2	123.5	18.2	4.0	7.5	11.9
	>IV	.1	--	2.2	.3	--	--	2.3	9.9	4.1	1.0	1.8	3.7	2.5
	TOTAL	258.2	272.8	613.0	170.0	290.0	120.0	207.0	185.0	143.0	95.0	14.0	36.6	66.0

Table 2. Continued

LAND CLASS		Jordan #4 Salt Lake	Utah	Juab	Wasatch	Sevier #5 Garfield	Piute	Sevier	Millard	Sanpete	Juab (East)	Juab (West)
						(in thousands of acres)						
Presently Irrigated	I	7.5	10.0									
	II	9.2	43.3	6.4		1.9	6.1	39.4	93.8	41.2	3.9	
	III	20.3	46.4	5.4	16.3	10.5	11.2	22.0	11.9	26.8	3.5	
	IV	11.0	26.3	1.2	9.1	1.5	1.9	1.4	1.3	6.5	.7	
	>IV	4.0	4.0	1.4	2.8	.1	.8	1.2	--	9.5	.9	
	TOTAL	52.0	130.0	14.4	28.2	14.0	20.0	64.0	107.0	84.0	9.0	0
Potentially Irrigable	I	13.1	11.4									
	II	23.8	54.1	14.5		14.8	3.4	4.0	121.3	7.1	39.2	32.1
	III	29.5	48.4	13.5	9.2	39.5	2.0	2.8	192.1	4.2	37.1	30.4
	IV	17.6	29.1	26.6	5.9	13.7	25.6	11.2	234.6	41.7	65.6	53.6
	TOTAL	84.0	143.0	54.6	15.1	68.0	31.0	18.0	548.0	53.0	141.9	116.1
Total Arable	I	20.6	21.4									
	II	33.0	97.4	20.9		16.7	9.5	43.4	215.1	48.3	43.1	32.1
	III	49.8	94.8	18.9	25.5	50.0	13.2	24.8	204.0	31.0	40.6	30.4
	IV	28.6	55.4	27.8	15.0	15.2	27.5	12.6	235.9	48.2	66.3	53.6
	>IV	4.0	4.0	1.4	2.8	.1	.8	1.2	--	9.5	.9	--
	TOTAL	136.0	273.0	69.0	43.3	82.0	51.0	82.0	655.0	137.0	150.9	116.1

Table 2. Continued

	LAND CLASS	Cedar-Beaver #6				Uintah #7			West Colorado #8				
		Iron	Beaver (Central)	Millard	Beaver (East	Daggett	Uintah	Duchesne	Garfield	Wayne	Emery	Grand	Carbon
		(in thousands of acres)											
Presently Irrigated	I	.3								.4	.5	.1	
	II	31.4	8.1		9.8		26.9	29.2	.6	.3	20.1	.1	7.6
	III	8.3	6.1		7.5	4.0	31.6	47.4	3.0	16.5	13.4	.2	9.0
	IV	5.6	1.0		1.2	3.9	15.1	31.1	.4	.6	6.3	--	1.4
	>IV	.4	.1		.2	1.7	10.7	16.2	--	.3	12.0	--	2.1
	TOTAL	46.0	15.3	0	18.7	9.6	84.3	123.9	4.0	18.1	52.3	.4	20.1
Potentially Irrigable	I	.2								1.0	1.0	5.0	
	II	163.1	26.6	26.6	9.7		62.9	36.4	7.8	12.1	46.9	25.6	20.4
	III	123.6	76.1	40.6	27.8	6.4	74.0	53.0	21.0	16.9	35.3	23.2	22.4
	IV	117.1	129.5	47.8	47.3	7.4	35.5	44.6	8.5	9.9	17.4	14.2	15.8
	TOTAL	404.0	232.2	115.0	84.8	13.8	172.4	134.0	37.3	39.9	100.6	68.0	58.6
Total Arable	I	.5								1.4	1.5	5.1	
	II	194.5	34.7	26.6	19.5		89.8	65.6	8.4	12.4	67.0	25.7	28.0
	III	131.9	82.2	40.6	35.3	10.4	105.6	106.4	24.0	33.4	48.7	23.4	31.4
	IV	122.7	130.5	47.8	48.5	11.3	50.6	69.7	8.9	10.5	23.7	14.2	17.2
	>IV	.4	.1	0	.2	1.7	10.7	16.2	--	.3	12.0	--	2.1
	TOTAL	450.0	247.5	115.0	103.5	23.4	256.7	257.9	41.3	58.0	152.9	68.4	78.7

Table 2. Continued

	LAND CLASS	Southeast Colorado #9			Lower Colorado #10	
		Grand	San Juan	Kane	Washington	Kane
		(in thousands of acres)				
Presently Irrigated	I	1.0			3.2	
	II	1.3		.8	10.9	1.0
	III	2.1	7.4	3.2	4.3	.9
	IV	.5	1.8	.4	.5	.1
	>IV	.1	.4	--	.1	--
	TOTAL	5.0	9.6	4.4	19.0	2.0
Potentially Irrigable	I	5.4			7.8	
	II	27.2	100.0	4.8	18.0	19.6
	III	24.4	252.1	13.5	44.0	59.4
	IV	15.0	83.2	7.8	41.5	53.8
	TOTAL	72.0	435.3	26.1	111.3	132.8
Total Arable	I	6.4			11.0	
	II	28.5	100.0	5.6	28.6	20.6
	III	26.5	259.5	16.7	47.8	60.3
	IV	15.5	85.0	8.2	42.8	53.9
	>IV	.1	.4	--	.1	--
	TOTAL	77.0	444.9	30.5	130.3	134.8

Source: PSIAC (1971 b, 1971 c, 1971 e, 1971 f); Pugh (1971); Shafer (1971); Utah Conservation Needs Committee (1970); Wilson, Hutchings, and Shafer (1968); Richardson (1970); Shafer (1972); and Wilson (1972).

4. Alfalfa + Barley + Nurse Acreage $\geq$ 7 (Sugar Beet Acreage)

5. Alfalfa + Barley + Nurse Acreage $\geq$ 7 (Corn Silage Acreage)

Alfalfa production is composed of two activities, alfalfa grown with either a full or a partial supply of water. Alfalfa is limited to a maximum of five years in succession, except in Daggett County, where, because yields are low and much of the hay is really grass hay, eight years are allowed. Then the land must be rotated, with at least one but not more than five years of barley and a nurse crop (except in Daggett County, where there is no barley activity). Corn silage and sugar beets are limited to 1/8 of the irrigated acreage where they can be grown. If these crops are both grown in a county, they are each limited to 1/9 of the total acreage. These rotation constraints allow numerous combinations of the crops (although only five of the combinations are economically feasible). If there is no water importation, a situation where water is in short supply may be met by one of three alternatives (or a combination of the three): 1) reduce the amount of land under irrigation. 2) Change to a crop rotation which is less water intensive. 3) Shift from producing alfalfa with a full supply of water to producing it with a partial supply (and a lower yield).

Corn and sugar beets are restricted from being grown in certain counties. Both of these crops are subject to crop failure due to late spring and early fall frost. This is particularly serious due to the heavy capital investment which is required (especially in sugar beet production). Heavy seasonal labor requirements in sugar beets also restrict production. Another factor which is both caused by and has helped to cause the sugar beet acreage restriction is the fact that all but one of the sugar refining plants in Utah have been closed. However, where they are successfully grown, these crops are very profitable. In the model, neither corn nor sugar beets may be grown on class IV land. Sugar beets are restricted, by upper bounds, to approximately their present acreage. When new land is brought into production, sugar beets may be planted on it in the same percentage as on the presently irrigated land. This being the case, Box Elder County in Region 2 is the only locality where sugar beet production in the model will approach that allowed by the rotation constraints. In any county where sugar beet production is allowed, the acreage will be controlled by either the upper bound or rotation constraint (whichever is lower). Table 3 summarizes the upper bounds on sugar beet acreage. According to data in the Utah Census of Agriculture, sugar beet acreage has been decreasing over time while corn silage production has increased rapidly. This being the case, no limits (other than the rotation constraints) are placed on silage acreage. This will allow corn silage production to increase over present levels.

The nurse crop activity is used to bring alfalfa hay into production. Alfalfa is planted along with barley. The barley is harvested the first year (with a lower yield and higher costs). Alfalfa hay is then produced for the next five years (eight in Daggett County). Every county has a nurse crop activity. Barley is grown in every county except Daggett. Irrigated pasture is allowed only on presently irrigated land which is classified as being poorer than class IV, and pasture is the only crop which is cultivated on that land.

Table 3. Upper bounds for sugar beets by land class in acres, Utah (on presently irrigated land)

	Land Class			Total
	I	II	III	
Region #2				
Box Elder	1,600	3,200	5,300	10,100
Cache	100	2,700	1,700	4,500
Region #3				
Weber	600	1,600	900	3,100
Davis	1,400	1,000	700	3,100
Region #4				
Salt Lake	700	800	1,900	3,400
Utah	400	1,800	1,900	4,100

Source: Utah Conservation Needs Committee (1972); U.S. Department of Commerce (1964); PSIAC (1971 b, 1971 c, 1971 e, 1971 f)

Dry-land wheat is restricted to potentially irrigable land in counties where "significant" amounts of it are already grown. Information from the U.S. Department of Commerce (1964, 1969) was used to determine the amount of non-irrigated land which is presently used for the production of hay, wheat, and barley. This value was used as the upper bound for the acreage in the dry-land wheat activity in each county in the Linear Programming model. These acreage constraints on dry-land wheat production are summarized in Table 4. (All upper bounds are detailed according to land class.) Wheat is grown every other year on a particular acre of land in an effort to conserve soil moisture. To approximate this situation in the L. P. model, all of the available land is planted each year but yields, cost, and other factors are reduced by one-half.

Costs of production

The agricultural budget information for this study was obtained from the "Greenbelt" budgets (Davis, Christensen, and Richards, 1972). The Utah State Legislature placed the Farm Land Assessment Act of 1969 (commonly referred to as the "Greenbelt Ammendment") on the state ballot, where it was ratified by the people of Utah. The legislation instructed the State Tax Commission to alter the taxation system for the state so that land could be taxed according to "use value". To do this, the land of the state was re-classified and the Tax Commission asked the USU Economics Department to determine an agricultural use value of privately owned land. In compliance, USU staff members determined land rental values and sales price, the crop rotation schedule, costs of production, yields, etc., in each of Utah's 29 counties.

Table 4. Upper bounds for wheat by potentially irrigable land class in acres, Utah

	Land Class				Total
	I	II	III	IV	
Region #1					
Box Elder	10,600	20,900	24,900	14,000	70,400
Tooele (east)	100	2,100	2,000	900	5,100
Region #2					
Box Elder	1,600	3,300	3,900	2,200	11,000
Rich	0	0	400	3,500	3,900
Cache	800	35,700	18,000	18,000	72,500
Region #3					
Morgan	0	0	0	4,600	4,600
Weber	100	500	1,800	2,300	4,700
Davis	0	400	700	600	1,700
Region #4					
Salt Lake	2,800	5,100	6,400	3,800	18,100
Utah	1,100	5,100	4,600	2,700	13,500
Juab	0	500	400	800	1,700
Region #5					
Juab (east)	0	1,200	1,200	2,100	4,500
Juab (central)	0	1,000	900	1,700	3,600
Millard	0	2,500	4,000	4,900	11,400
Sanpete	0	700	400	4,000	5,100
Region #9					
San Juan	0	4,000	10,200	3,400	17,600
Region #10					
Washington	200	400	1,000	900	2,500

Based on: 1964 U.S. Census of Agriculture and Revised Potentially Irrigable Land Classifications from the Framework Studies.

Source: U.S. Department of Commerce (1964); PSIAC (1971 b, 1971 c, 1971 e, 1971 f).

The "Greenbelt" figures were revised slightly for this study to make them more applicable to the water allocation problem. The costs associated with the production activities were divided into their average and variable components. The definitions of average and variable costs which follow are not the typical economic definitions. They are being used for convenience and to clarify the input information. Average costs may be viewed as being "fixed" once the decision is made and implemented to grow a certain crop. Average costs are those costs, such as fixed overhead, seed, and plowing, which must be met before production can occur. They are summarized in Appendix A in Table 8. Variable costs are those costs which vary with the amount of output, the number of cuttings, or the number of irrigations. Variable costs are assumed to be the same throughout the state, while average costs may be slightly different due to a difference in production activities. Variable costs are found in Table 5.

Yields and prices

Information from the U.S. Department of Commerce (1964, 1969); Davis, Christensen, and Richards (1972), and PSIAC (1971 a, pp. 128-131; 1971 d, pp. 45, 129-132, and 137) was used to estimate yields by land class and county. The base figures were obtained from the Census and "Greenbelt" studies and they were projected to 1980 for each region according to revised yield increase projections found in the report by the PSIAC (1971 a, pp. 128-131; 1971 d, pp. 45, 129-132, and 137). Curtailment of fertilizer and pesticide use due to environmental concern could cause the actual productivity increases to be lower than projected.

Table 5. Normalized variable costs of production--Utah

Activity	Unit	Cost Component	Cost	Total Cost
Barley Production	Bushel	Cash Cost	$ .13	$ .15
	Bushel	Labor Cost	.02	
Corn Silage Production	Ton	Cash Cost	1.65	2.25
	Ton	Labor Cost	.60	
Sugar Beet Production	Ton	Cash Cost	3.00	3.40
	Ton	Labor Cost	.40	
Alfalfa Production	Ton	Cash Cost	4.80	8.00
	Ton	Labor Cost	3.20	
Alfalfa Production	Cutting	Cash Cost	2.90	3.70
	Cutting	Labor Cost	.80	
Wheat Production	Bushel	Cash Cost	.05	.08
	Bushel	Labor Cost	.03	

Source: Davis, Christensen, and Richards (1972).

It is also possible, however, for the yielded projections to be somewhat lower than the actual productivity due to improved technology and farming methods and the adoption of those innovations. Brigham Young University has been testing a new type of alfalfa which may be an example of this output increasing technology. On rocky soil, they have been experiencing yields of up to eight tons per acre (Herald Journal, 1972).

Projections of past trends (Daly and Egbert, 1966; Pacific Southwest Inter-Agency Committee, 1971 a, 1971 d; Economic Report of the President, 1968; and Christensen and Richards, 1969) were used to estimate input-output relations and prices for the year 1980. The prices used are found in Table 6.

Water use

A revised Blaney-Criddle model was used (see U.S. Dept. of Agriculture, Soil Conservation Service, 1967; and Criddle, Harris, and Willardson, 1962) along with climatic information from Richardson (1971) and other sources to determine the consumptive irrigation water use requirement for every crop in each county in each hydrologic subregion. Estimated supply from soil moisture storage and effective precipitation was subtracted from potential consumptive irrigation requirements for each crop. These consumptive use figures for each subregion were transformed into quantity diverted values by the L.P. model through the use of irrigation system efficiency factors which have been developed for each region (see Clyde, King, and Andersen, 1971; and King, 1972). These efficiency factors, which vary from

Table 6. Normalized prices of agricultural commodities--Utah

Crop	Unit	Price
Alfalfa	Ton	$ 27.00
Barley	Bushel	1.20
Sugar Beets	Ton	16.00
Corn Silage	Ton	9.00
Pasture	Animal Unit Month	4.00
Wheat	Bushel	1.35

Source: Daly and Egbert (1966); PSIAC (1971 d); Economic Report of the President (1968); Christensen and Richards (1969).

region to region, account for groundwater recharge, evaporation while in transit, and other such water losses.

Evidence would seem to indicate that the evapotranspiration-crop yield relationship is virtually linear over the relevant range for the crops used in this study (Stewart and Hogan, 1969). This implies that a logical approach would be to use a single water level and yield for crops other than alfalfa. Alfalfa would require more than one water and yield level because of the possibility of raising a different number of crops (cuttings) during the growing season (Anderson, 1972). This being the case, the revised Blaney-Criddle model was used to determine a "full" water supply level for all of the irrigated crops used in the study except alfalfa, which has two levels of yield and water use in each county. See Appendix A, Table 8.

The irrigation hours estimates were based directly on the crop involved and upon the irrigation consumptive use. It was estimated that the first watering on alfalfa, barley, nurse crop, and pasture would require 1 hour and that each subsequent irrigation would take 3/4 of an hour. It was assumed that the first irrigation on corn would require 1½ hours and that each watering after that would take 1 hour. The first watering of sugar beets was estimated to require 2 hours, the next two waterings 1½ hours each, and each irrigation after the third, 1 hour. The consumptive use figures which were obtained from the revised Blaney-Criddle model were used to determine the number of irrigations for each crop in each county. It was estimated that alfalfa, nurse crop, and corn would consumptively use .4 acre-feet of water per irrigation; that barley and pasture would require .3 acre-feet per watering; and that sugar beets would require .25 acre-feet. To determine the number of irrigations involved, the amount of water used per irrigation was divided into the consumptive use requirement for that crop in each area. Any value that was .25 of an irrigation or greater was rounded up to the next irrigation. Labor was assumed to command a price of $2.00 per hour. The non-variable costs of production, labor requirements, yield levels, water requirements, and other input information for each crop are summarized in Appendix A, Table 8.

Costs of bringing potentially irrigable land into production

Several sources were used to determine the costs of bringing potentially irrigable land into irrigated production. Included in these sources are Wilson (1969); U.S. Department of the Interior, Bureau of Reclamation (1957, 1961, 1964); Stewart (1960); PSIAC (1971 c, 1971 f); U.S. Department of Agriculture (1958); and conversations with representatives of the Logan S.C.S. office. These sources were used to approximate the costs of bringing each potentially irrigable land class into irrigated production. Data from the U.S. Department of Commerce (1964, 1969) and information from the Economic Report of the President (1968) were used to update these cost estimates. The development cost on a yearly basis was obtained by using an interest rate of 7%. Table 7 summarizes these costs for potentially irrigable land. It was estimated that the operation and maintenance cost (O & M) of existing distribution networks would be $1.00 per acre on presently irrigated land. This charge is found in the demand portion of the

Table 7. Yearly costs of preparing potentially irrigable land for irrigated production by land class using 7% interest rate, Utah

Region	Land Development Costs				Distribution Costs				Total Cost			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
1	$4.10	$5.30	$6.20	$7.50	$3.00	$3.00	$3.00	$3.00	$ 7.10	$ 8.30	$ 9.20	$10.50
2	4.10	5.30	6.20	7.50	4.00	4.00	4.00	4.00	8.10	9.30	10.20	11.50
3	4.10	5.30	6.20	7.50	5.00	5.00	5.00	5.00	9.10	10.30	11.20	12.50
4	4.10	5.30	6.20	7.50	6.00	6.00	6.00	6.00	10.10	11.30	12.20	13.50
5		5.30	6.20	7.50		4.00	4.00	4.00		9.30	10.20	11.50
6	4.10	5.30	6.20	7.50	5.00	5.00	5.00	5.00	9.10	10.30	11.20	12.50
7		5.30	6.20	7.50		3.00	3.00	3.00		8.30	9.20	10.50
8	4.10	5.30	6.20	7.50	3.00	3.00	3.00	3.00	7.10	8.30	9.20	10.50
9	4.10	5.30	6.20	7.50	3.00	3.00	3.00	3.00	7.10	8.30	9.20	10.50
10	4.10	5.30	6.20	7.50	3.00	3.00	3.00	3.00	7.10	8.30	9.20	10.50

Sources: Wilson (1969); U.S. Department of the Interior, Bureau of Reclamation (1957, 1961, 1964); Stewart (1960); PSIAC (1971 c, 1971 f); U.S. Department of Agriculture (1958); U.S. Department of Commerce (1964, 1969); and Economic Report of the President (1968).

model. Additional O & M costs vary with the number of acre-feet used (see King, 1972). This refers to the fact that the supply model contains an O & M charge on each acre-foot of diverted water. Therefore, the more water an acre of land uses, the greater will be the total O & M cost.

RESULTS OF THE ANALYSIS

Region 1 (Desert):

The region covers most of the eastern portion of the state from the Idaho border down to Iron county. As the name implies, it is extremely dry and barren with relatively little water and little irrigated agriculture. There is also very little industry, and most of the region is sparsely populated. As a result, the municipal and industrial water needs are quite low and little actual development is expected for the future. Figure 6 shows the derived demand curve for irrigation water and the three supply curves depicting the situation in the years 1965 (when approximately 10,000 acre-feet of water was used for M & I purposes), 1980 (with M & I use projected at 13,000 acre-feet), and 2000 (when 18,000 acre-feet of water may be provided for M & I uses). The equilibrium point for 1965 is at a quantity of 124,000 acre-feet of irrigation water and a price of $5.24/A.F. The projected equilibrium for 1980 is at the same price, while quantity drops to 122,000 acre-feet and the 2000 equilibrium point shows a further drop to 119,999 acre-feet with no change in price. Virtually all of the available water is now and can be expected in the future to be used for agricultural production. Studies have shown (King, 1972) that the actual amount of water used for agricultural production in the region in 1965 was 124,000 acre-feet on about 47,000 acres. Amazingly, this is the exact equilibrium water quantity point which was identified by the model. However, the model indicates that it would be

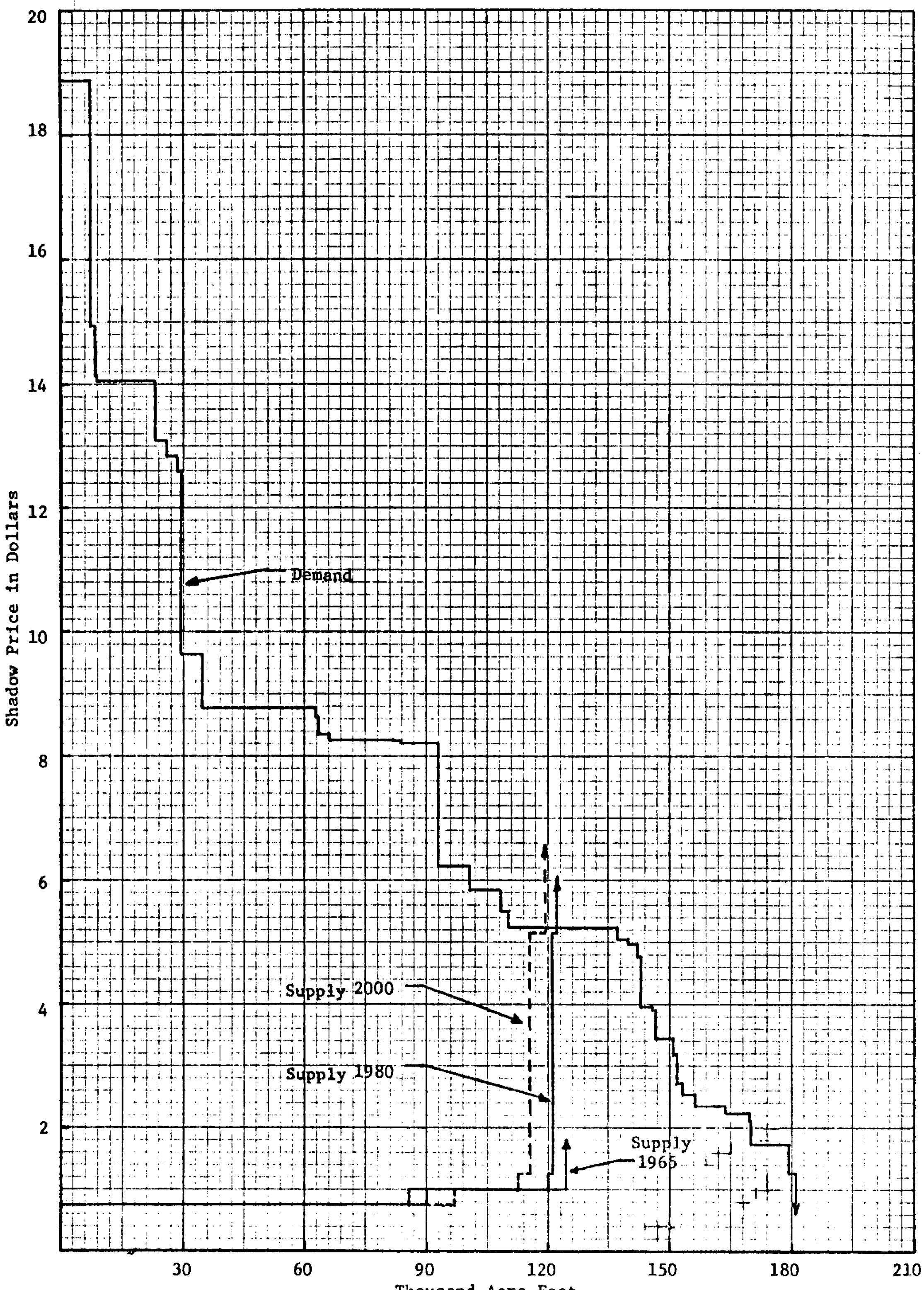

Figure 6. Demand function for water on presently irrigated land and supply functions for 1965, 1980, and 2000 (Region 1 - Great Salt Lake Desert)

profitable to release water from use on the poorer yielding lands for use on higher quality land if this transfer could occur within an existing water system.

The schedule (D_1^1) in Figure 7 represents the demand curve for water on potentially irrigable land where the best land may be cultivated first, while the second curve (D_2^1) represents the situation where all classes (I-IV) of land must be brought into cultivation together.

Because of the water shortage in this region, yields could be increased by also using additional water for supplemental irrigation on land which is presently under cultivation. The demand for water for development exists, but there is simply no excess water within the region to meet that demand. If any new development is to occur, the water will have to be imported from one of the other regions. The fact that the best agricultural land is separated from the major sources of water by high mountain ranges and the Great Salt Lake makes it economically, if not technically, unrealistic to consider such a project. The only such importation scheme which might work would be to export water from Region 2 into western Box Elder County in Region 1. Because Region 2 has a steadily growing demand for water, it is doubtful if much water could be released for this purpose. The estimated average cost of importing water into Region 1 in this manner is \$14.20 per acre-foot. Assuming the water were available in sufficient quantities, little development could actually take place for two main reasons. First, only a small portion of the region could be supplied because of the mountains and the lake. Second, this cost is almost as

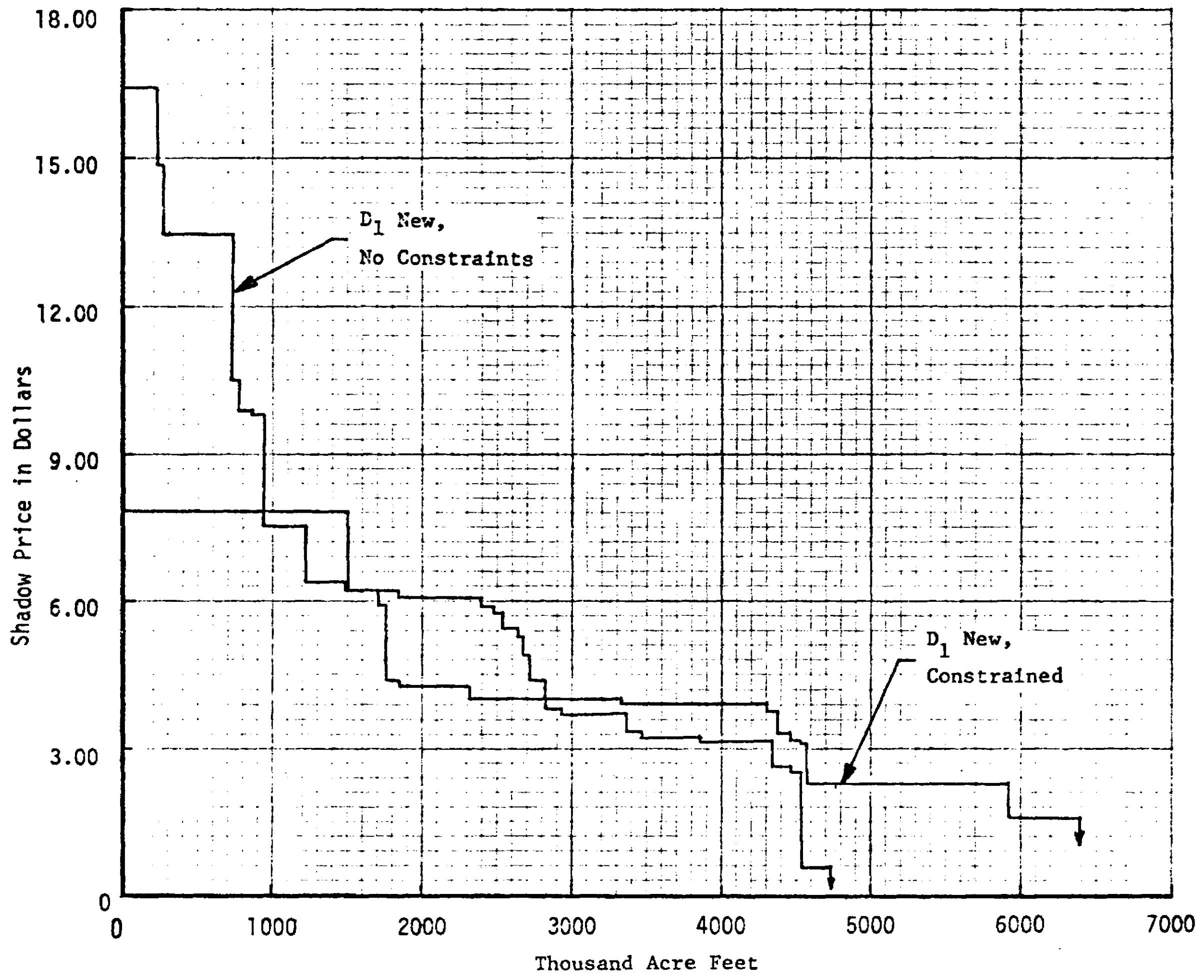

Figure 7. Demand for irrigation water on new land where development is, and is not, constrained to develop poor land with good land (Region 1 - Great Salt Lake Desert)

great as the maximum shadow price of water in production under the best of conditions ($16.50) and is much higher than the less optimistic maximum ($7.84). This being the case, the true situation lies somewhere between. Therefore, the cost will either be higher than the high point of the true demand curve or it will intersect it at a very high price and a very low water use level. Under the best of circumstances, only about 265,800 acre-feet of water would be used if the water could be imported for this price to the entire region. Since the area of western Box Elder County could only use a fraction of this amount, it is doubtful if the realities of scale would even allow the water to be imported at that low price. In short, it appears that with our given level of technology and the given water supplies in the nine other regions, the importation of water into Region 1 would not produce a sufficient net return to meet the total importation cost even though there are about 1,676,000 acres of potentially irrigable land in the region.

Region 2 (Bear River):

This region, located in the upper northeast corner of the state, is one of the three or four most productive areas in Utah. Approximately 246,000 acres are presently irrigated and there is an ample supply of water available for use in agricultural production. Some industry has entered the area and projections show that great increases in water use for municipal and industrial purposes will occur. However, agriculture will continue to be the greatest water use in the subregion.

The demand curve in Figure 8 represents the demand curve for water to be used on presently irrigated land. The supply curve for

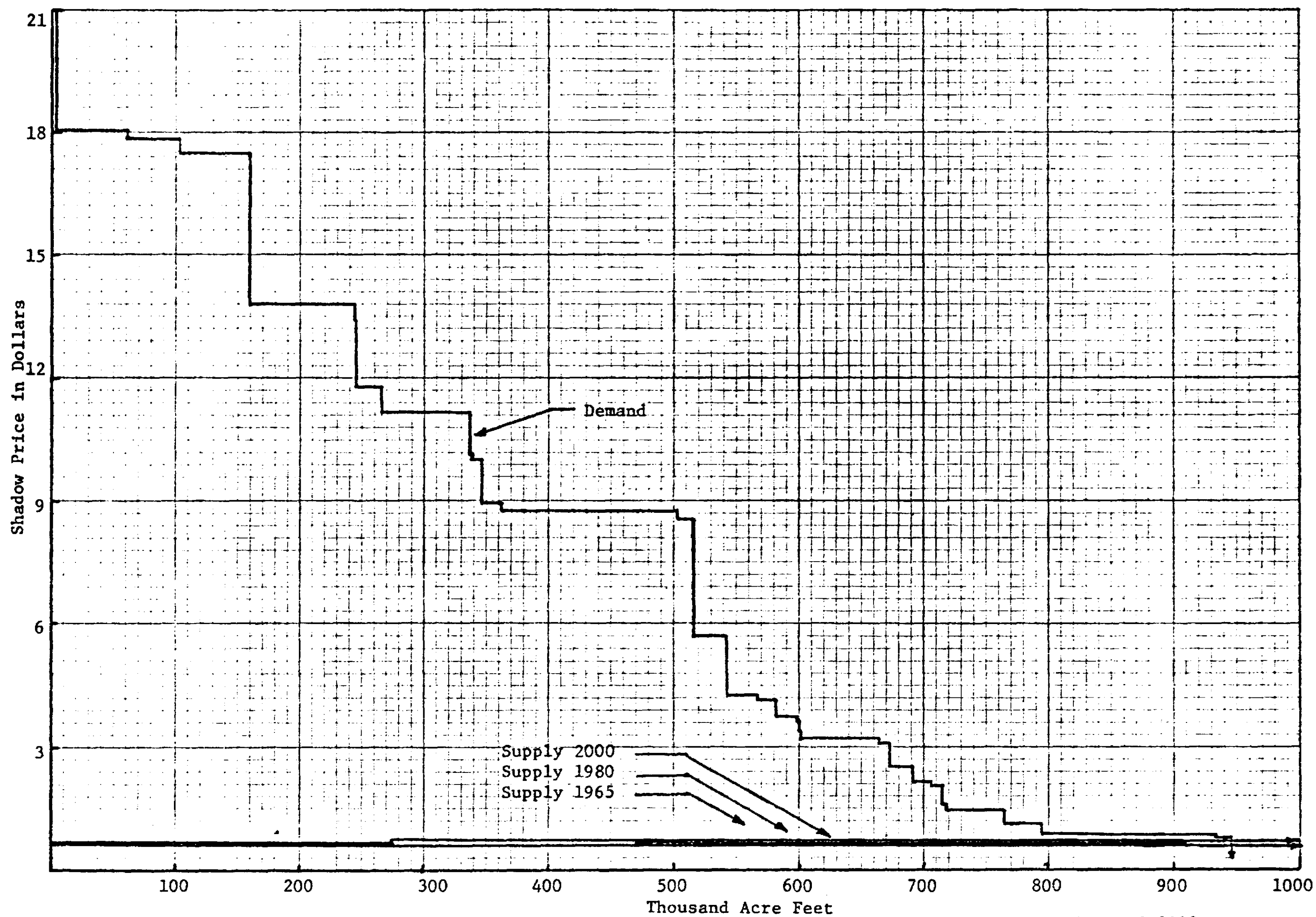

Figure 8. Demand function for water on presently irrigated land and supply functions for 1965, 1980, and 2000 (Region 2 - Bear River)

1965 was based on municipal and industrial use of 44,000 acre-feet. The projected M & I values upon which the 1980 and 2000 supply curves are based are 108,000 and 194,000 acre-feet, respectively. Because there is such a large supply of water available, the increase in M & I use doesn't affect the supply curves until the level of water use in agriculture reaches a point above 1,000,000 acre-feet (Appendix Table 10). The equilibrium point for each year is the point where price equals $.75 and quantity is 945,500 acre-feet.

It has been estimated by King (1972) that approximately 1,034,000 acre-feet of water was used for irrigation purposes in the region in 1965. This represents a variation, from the level estimated by the model, of about 8.6 percent. This difference could be due to an error in estimating the actual use, to the efficiency factor being too high in the model, to improper acreage estimates in either study, or to any combination of underlying assumptions and other factors. It was not expected that the model would predict perfectly. The model was only intended to be an approximation of the "real world" situation. A difference of only 8.6 percent would indicate that the model does just that.

Approximately 289,000 acres of potentially irrigable land are located within this region and it would appear that there is enough water in the region to bring some of this land into production. The demand curve D_1^2 in Figure 9 represents the situation where the most productive land can be brought into cultivation first, while the second demand curve, D_2^2, represents the demand for irrigation water on potentially irrigable land when all four classes of land are

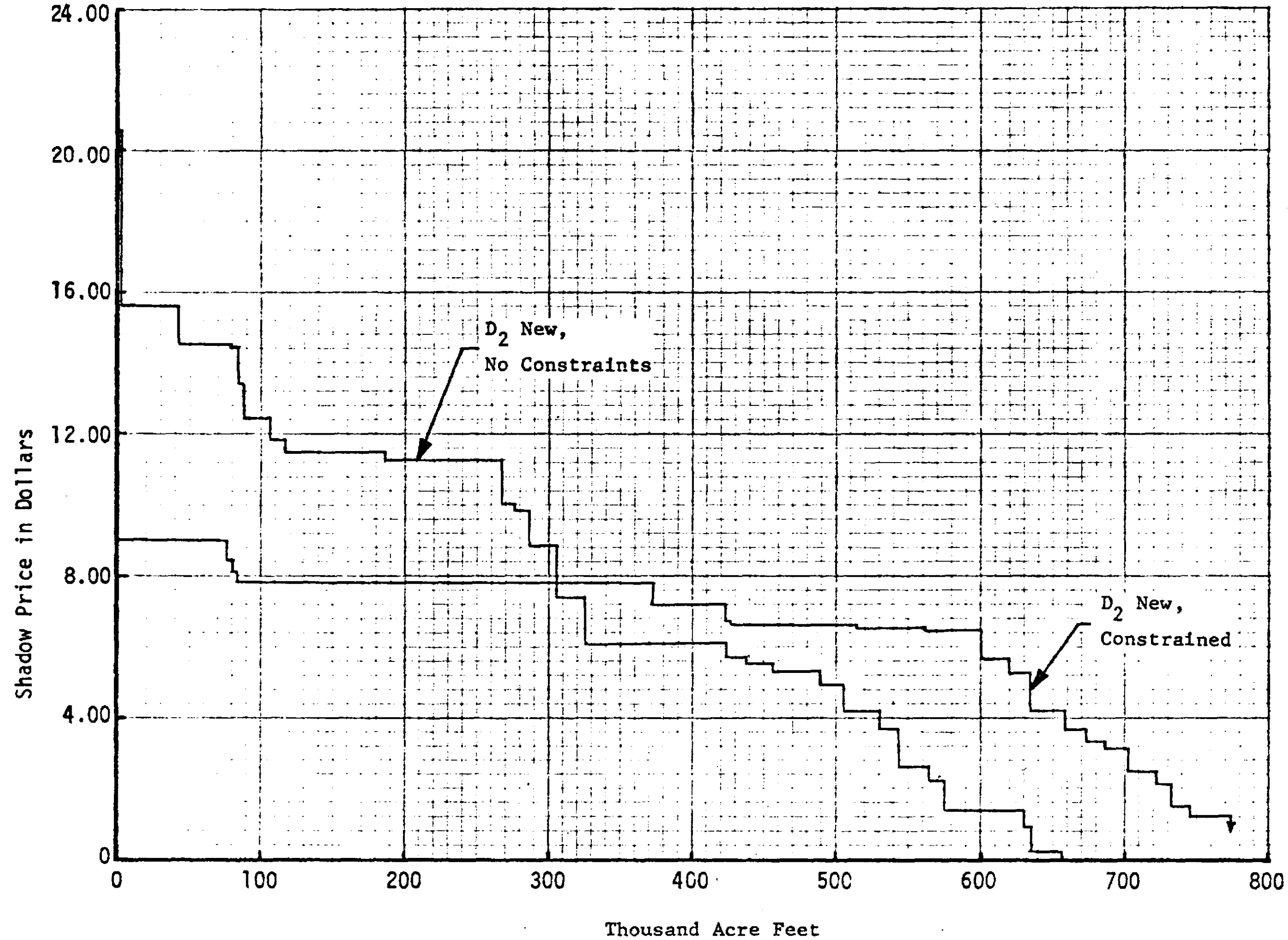

Figure 9. Demand for irrigation water on new land where development is, and is not, constrained to develop poor land with good land (Region 2 - Bear River)

brought into production together. The three supply curves, one for each of the years 1965, 1980, and 2000, are what has been referred to as "residual" supply curves. They represent the portion of each of the supply curves which lie to the right of the equilibrium points in Figure 8. The quantity of water which would be used on presently non-irrigated land during each of the three years would be the same regardless of which demand curve is used. There is a difference, depending on the underlying assumptions, in the value of the water at this equilibrium level. The model shows an equilibrium level of 293,500 acre-feet in 1965 with a value of $8.96 if D_1^2 is used and $7.81 if D_2^2 is used. The equilibrium level in 1980 is 237,500 acre-feet and the D_1^2 value is $11.33, while the D_2^2 value is $7.81. By the year 2000, the quantity is shown to have decreased greatly to 93,500 acre-feet with a D_1^2 price of $12.50 and a D_2^2 price of $7.81. Although enough water is presently available within the region for agricultural development to occur, it appears that industrial and municipal developments may curtail this development. Barring imports, if new land is developed now, much of it would later have to be removed from production to release the water for M & I uses by the year 2000.

Water importations from other parts of the state appear economically impractical because of the region's location. The projected cost of such imports appears to be greater than the net benefit which could be obtained from the water by the farmer.

There are some lands in this region which have an inadequate supply of water. The yields on these lands could be significantly increased at a very small expense by increasing the water application.

However, such lands represent a very small portion of the total irrigated problem so there is very little potential for development in this manner.

Region 3 (Weber):

The productivity of irrigated agriculture is high in this region. It is also an area of rapidly expanding population and industry and these uses have removed much of the best farm land from agricultural production. Since this trend is projected to continue, it is doubtful if any new agricultural development will take place here. In fact, the reverse is much more likely.

Approximately 159,700 acres of land is presently under irrigated production, with most of it receiving an ample supply of water. Most of the best farm land has already been brought into production and that which remains is of poorer quality. There are approximately 51,900 acres of potentially irrigable land; however, this is a very small amount when compared to most of the other hydrologic subregions within the state. A large supply of water is available at a modest cost for the presently irrigated land. However, the marginal cost of the water increases sharply in the "residual" supply functions.

Figure 10 shows the supply functions for the years 1965, 1980, and 2000, which are based on estimated municipal and industrial uses of 49,700, 126,000, and 227,000 acre-feet of water, respectively. The equilibrium point is the same for all three years with a price of $1.54 per acre-foot and a quantity of 611,000 acre-feet of water. The demand model makes no allowance for encroachment of businesses and residential

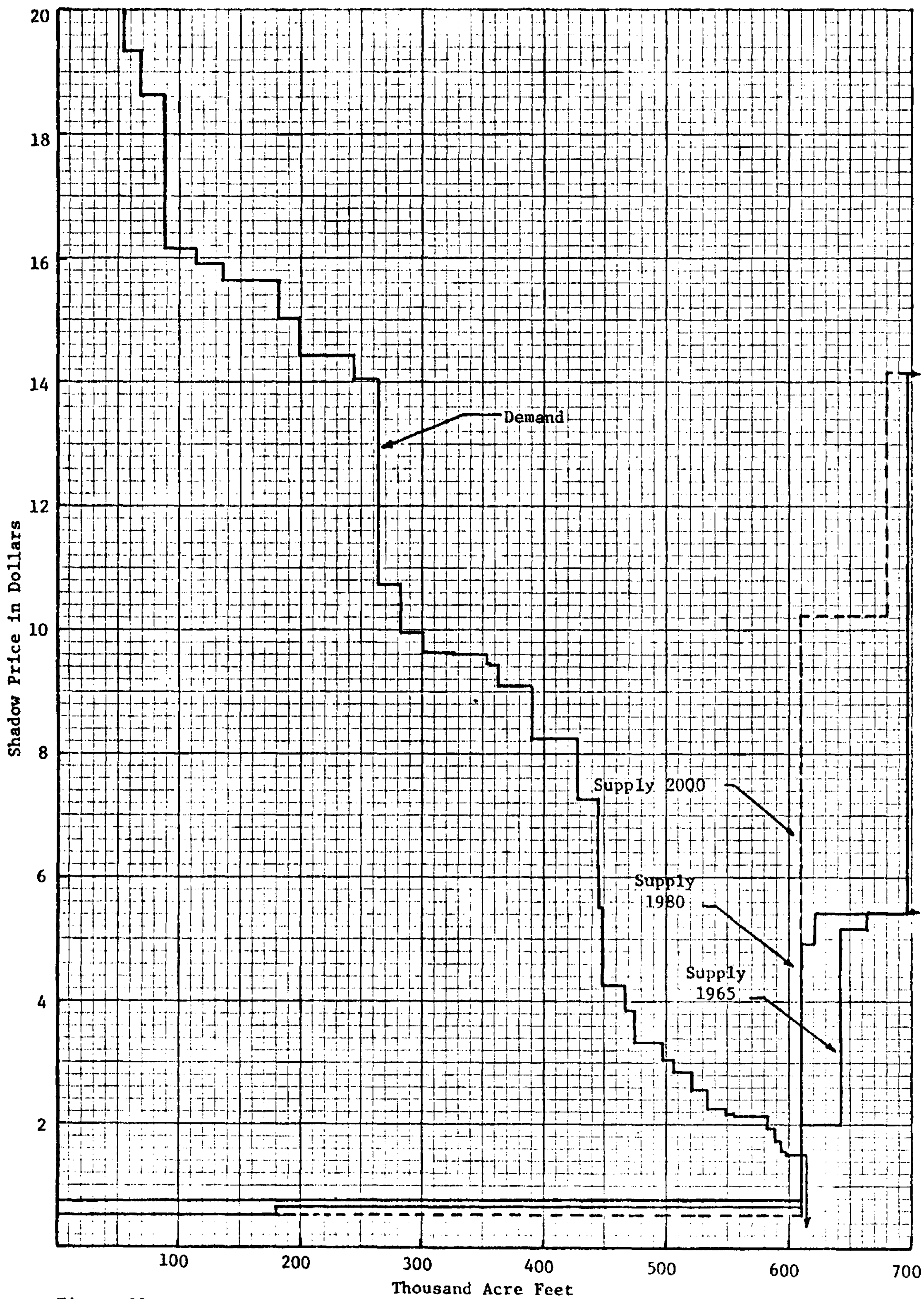

Figure 10. Demand function for water on presently irrigated land and supply functions for 1965, 1980, and 2000 (Region 3 - Weber River)

areas on farm land. The probable result of this would be to cause the equilibrium point to be where a lower quantity of water would be demanded in each of the two subsequent time periods, probably at a lower price. The actual water use has been estimated by King (1972) to be 797,000 acre-feet. The difference could be due to many factors, some of which are mentioned in the statements concerning Region 2. The most likely explanation is that the acreage estimates differ (they are constantly changing) and/or farmers are using a greater than optimal water use level on their lands.

Figure 11 would tend to indicate that there may be some opportunity to bring new land into irrigated production, at least in the short run. The "optimistic" intersection point for 1965 is at a price of $5.42 per acre-foot and the corresponding quantity is 89,400 acre-feet. The less optimistic and more realistic value is $5.18 per acre-foot and 46,700 acre-feet. In 1980, the two equilibrium points are $5.91 per acre-foot with 88,000 acre-feet and $5.40 per acre-foot with only 11,000 acre-feet of water. In the year 2000, the projected equilibrium point for the higher demand curve is at a price of $10.23 per acre-foot and 23,800 acre-feet of water. The lower curve indicates that no development would occur under the supply situation which is expected in 2000. This region has a problem similar to that found in Region 2. However, the situation regarding development is more pronounced in Region 3 because there is less potentially irrigable land, the land that could be irrigated is of lower quality, and the industrial growth is expected to be greater and more rapid. Therefore, little, if any, actual agricultural development is expected unless

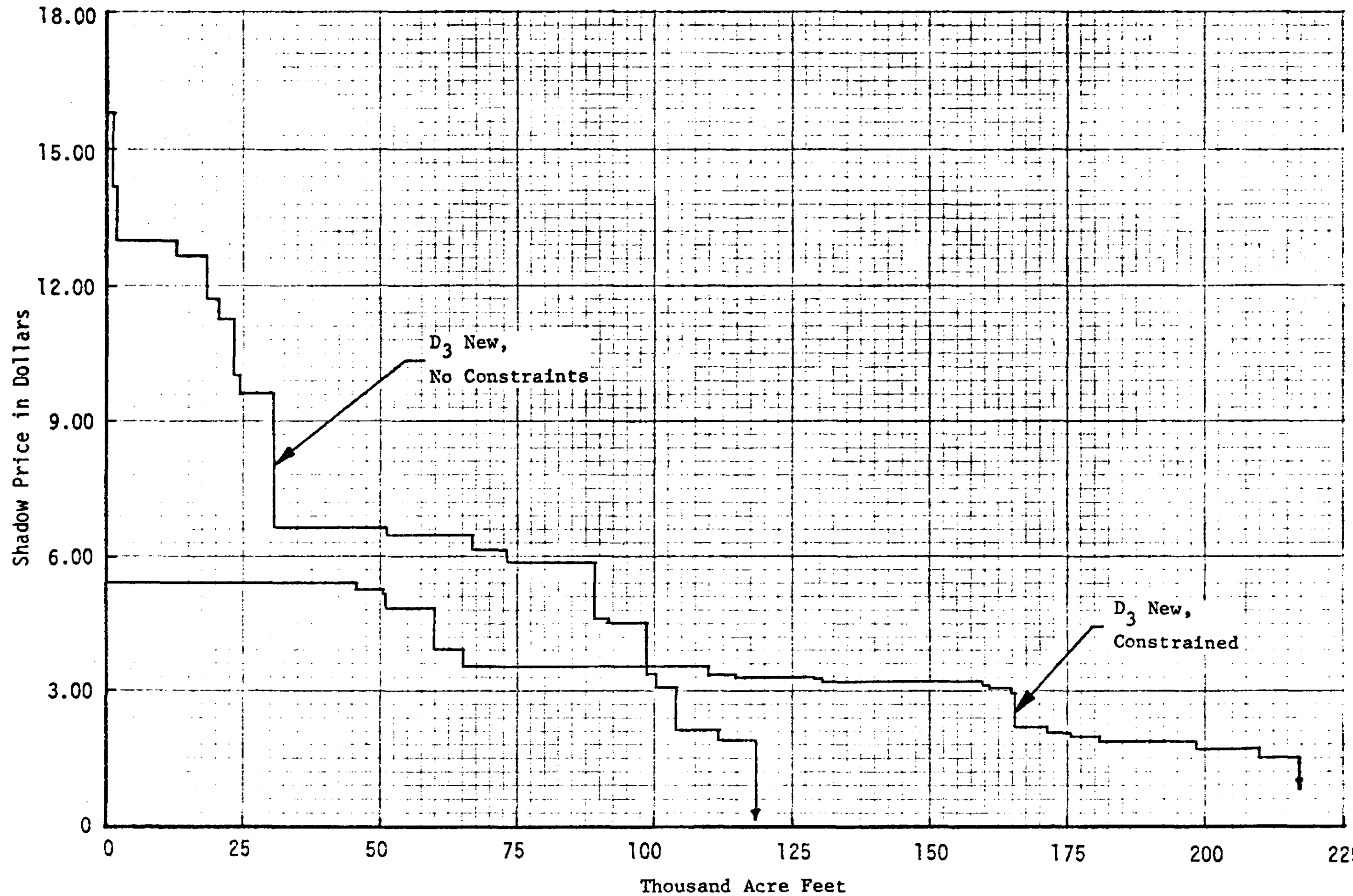

Figure 11. Demand for irrigation water on new land where development is, and is not, constrained to develop poor land with good land (Region 3 - Weber River)

water is imported into the region. Even then, the water could be used for M & I purposes and much of the best farm land might be completely taken out of agricultural production.

According to King (1972), it would cost about $20.20 per acre-foot to import water from the Uintah basin into Region 3 on a large scale for irrigation use, and it would cost about $13.95 per acre-foot to import water from Region 2 into Region 3. As Figure 11 shows, even under extremely optimistic conditions, the cost is so great that the benefit received by the farmer would be insufficient to bear the entire burden of meeting the cost of importing the water.

Region 4 (Jordan):

The heart of Utah's industry and the bulk of her population are found in Region 4. The farm land is fertile and the existing water supplies are adequate for full irrigation of most of the land which is presently under irrigated cultivation. It is projected that great industrial growth will remove much of the approximately 224,600 acres of presently irrigated land from agriculture. This will have the same effect on the demand for water in agriculture as was explained in relation to Region 3. In spite of the fact that much intensive agriculture and industrial growth are found in the region, there are large areas of potentially irrigable lands. Presently, approximately 296,700 additional acres of land could be brought under irrigation if the lands were prepared and the water available.

Figure 12 shows the demand schedule for water for use on presently irrigated land in this region. The supply curve representing 1965 is based on municipal and industrial water use of 302,500 acre-feet, while

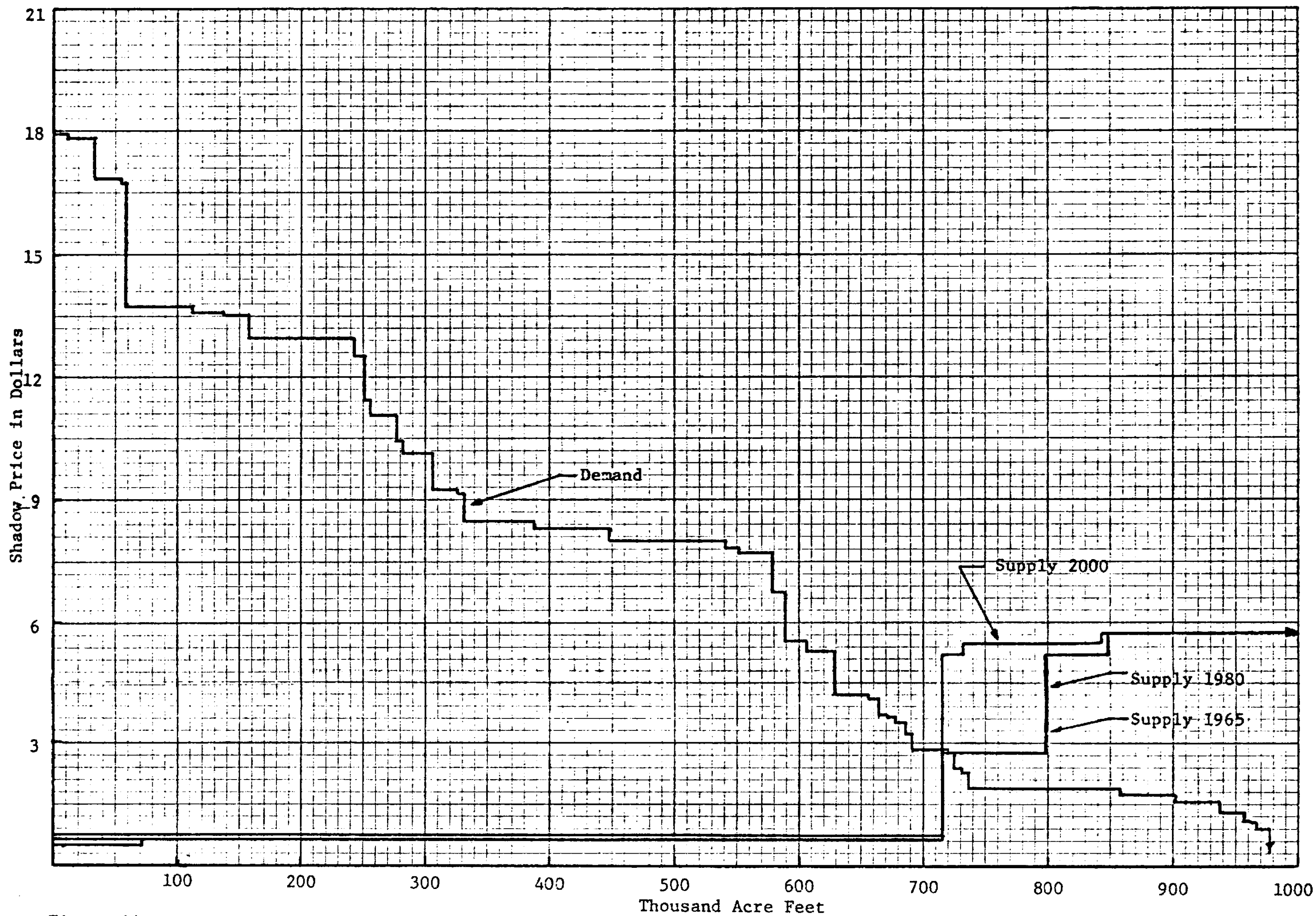

Figure 12. Demand function for water on presently irrigated land and supply functions for 1965, 1980, and 2000 (Region 4 - Jordan River)

the curves for 1980 and 2000 are based on projected M & I use of 517,000 and 803,000 acre-feet of water, respectively. Because of the large supply of water in the region, the equilibrium point over the time period varies very little in spite of the great increase of water use for municipal and industrial purposes. The graph indicates that the equilibrium point for 1965 is at 719,000 acre-feet of water at a price of $2.75 per acre-foot. The equilibrium point for 1980 and 2000 are at 715,000 acre-feet of water and a price of $2.83. The graphical analysis indicates that some of the least productive land which is presently irrigated should be removed from irrigated production because the marginal cost of applying water to that land is greater than the marginal benefit derived from the use of that unit of water. King (1972) estimated that 797,000 acre-feet of water was actually used on irrigated land in 1965. The difference here is due to the fact that land, which the marginal analysis of the model indicates probably should not have been irrigated, was actually watered. Other factors may also have contributed to the difference.

Figure 13 indicates that there is significant opportunity for bringing potentially irrigable land into production using the water supplies which are already found within the region. However, as in Regions 2 and 3, any such development would be short-lived, barring large scale importation of water, because industry and municipal uses are expected to take much of the arable land and agricultural water. The equilibrium level of water use for new development in 1965 is at 412,000 acre-feet and an expected price ranging between $6.83 and $7.86 per acre-foot. By 1980, the model shows that the quantity level

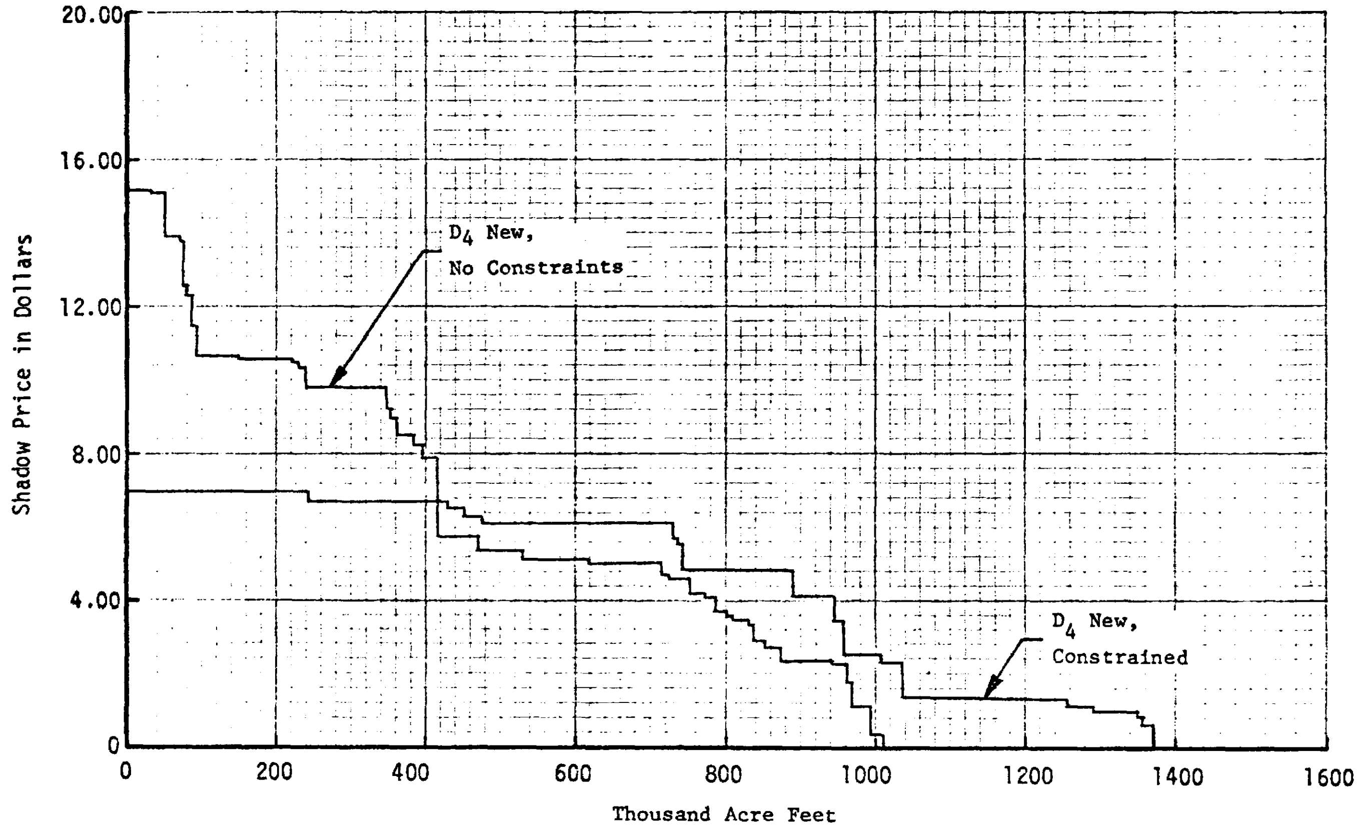

Figure 13. Demand for irrigation water on new land where development is, and is not, constrained to develop poor land with good land (Region 4 - Jordan River)

would drop to 248,000 acre-feet within the price range of \$6.83 and \$9.79 per acre-feet. By 2000, the model implies that there would be little, if any, irrigation of land which is not presently irrigated. The equilibrium level for the year 2000 is located at a quantity of only 16,000 acre-feet with a broad price range between \$7.00 and \$15.24 per acre-foot. However, there are some areas, such as Cedar Valley, located west of Utah Lake, where industry is not likely to locate and where some permanent irrigation projects might be completed if adequate supplies of water are available.

The estimates prepared by King (1972) indicate that a conservative estimate of the average cost of importing water into Region 4 from the Bonneville Unit of the Central Utah Project would be \$28.55 per acre-foot, the cost from the Ute Indian Unit would be about \$31.55, and the water coming from Region 7 through the Sevier area to Region 4 would cost about \$29.55 per acre-foot. Importing water from Region 3 would cost about \$25.55. All of these costs are higher than the marginal benefit to the farmer at any level of production.

Region 5 (Sevier):

Portions of Region 5 are quite fertile and produce high yields. However, the region as a whole suffers from a shortage of water. Additional supplies of water would be helpful for supplemental irrigation as well as for possible development. Approximately 298,000 acres are presently under irrigation and another 976,000 acres could be brought into cultivation if adequate supplies of water were available. A small amount of municipal and industrial growth is projected for the area by 2000, but not enough to significantly affect the agricultural industry.

The supply functions of Figure 14 were developed under the assumption that municipal and industrial water use in 1965 was 17,000 acre-feet and that it will be 21,000 acre-feet in 1980 and 26,000 acre-feet in 2000. The equilibrium level of water use in 1965 is shown by the model to be at 890,000 acre-feet and a price of \$7.32. In 1980 and 2000, the equilibrium price remains at \$7.32, while the equilibrium quantities are approximately maintained at 885,000 acre-feet and 880,000 acre-feet, respectively.

The analysis of this hydrologic subregion presents some unique and interesting problems. King (1972) estimates that the actual water use in 1965 was 1,018,000 acre-feet of water. The model shows an equilibrium level at only 890,000 acre-feet while using almost all of the available water. The reason for this apparent difference is found in the assumptions underlying the supply portion of the model. It was assumed that the farmers can not continue to mine water from the ground at the present rate for any great duration of time because they are significantly lowering the water table (King, 1972). A level of water mining was built into the model which would lead to a more stable water table level. Consequently, not only can no significant new development occur in the region without importation of water, as is shown in Figure 15, but much of the presently irrigated land will also be forced out of production as the water table lowers or as more stringent controls are placed upon water mining.

Depending on the source project, King (1972) has estimated that the average cost of importing Colorado River water into Region 5 would range between \$21.75 and \$30.75 per acre-foot, while it would cost

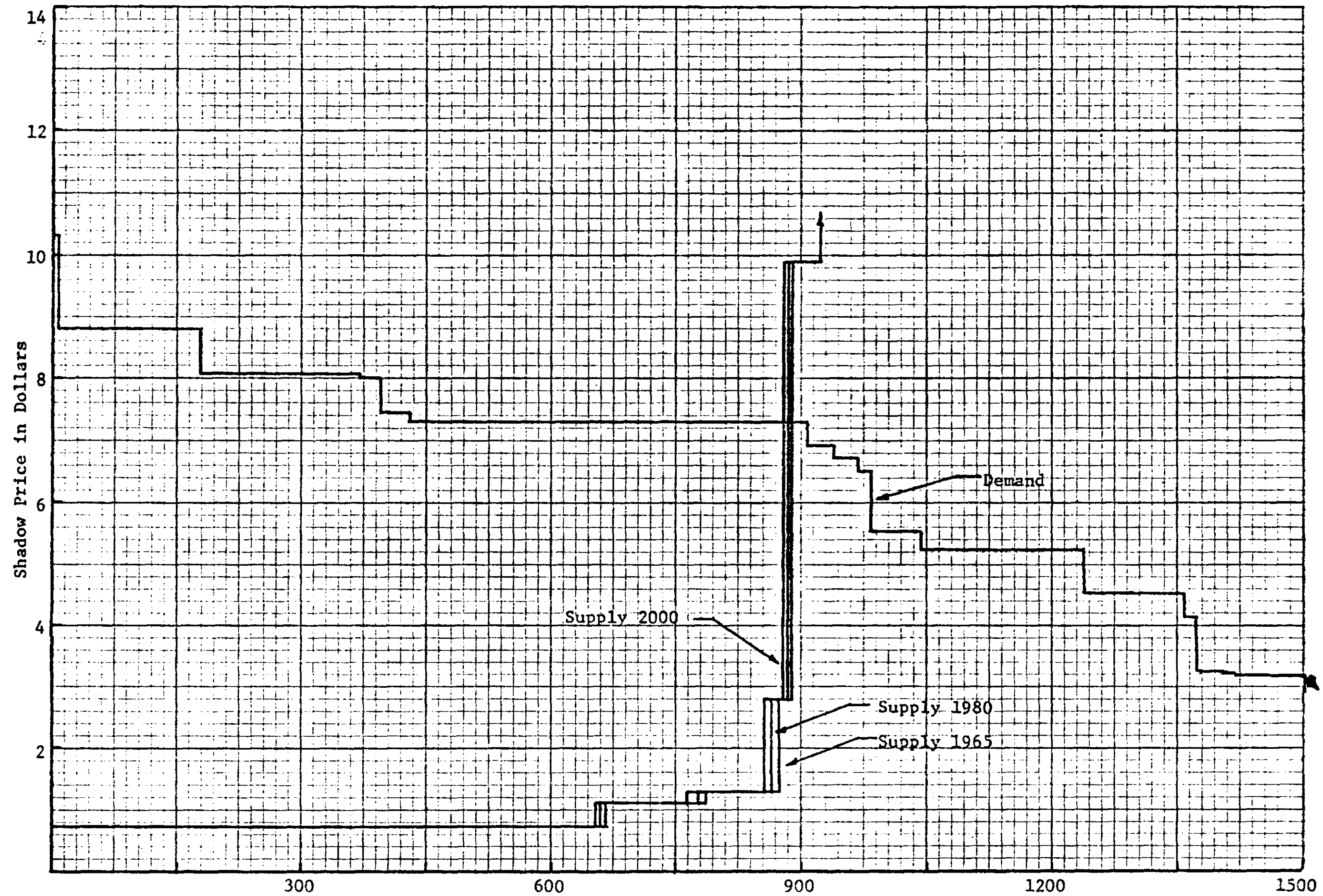

Figure 14. Demand function for water on presently irrigated land and supply functions for 1965, 1980, and 2000 (Region 5 - Sevier River)

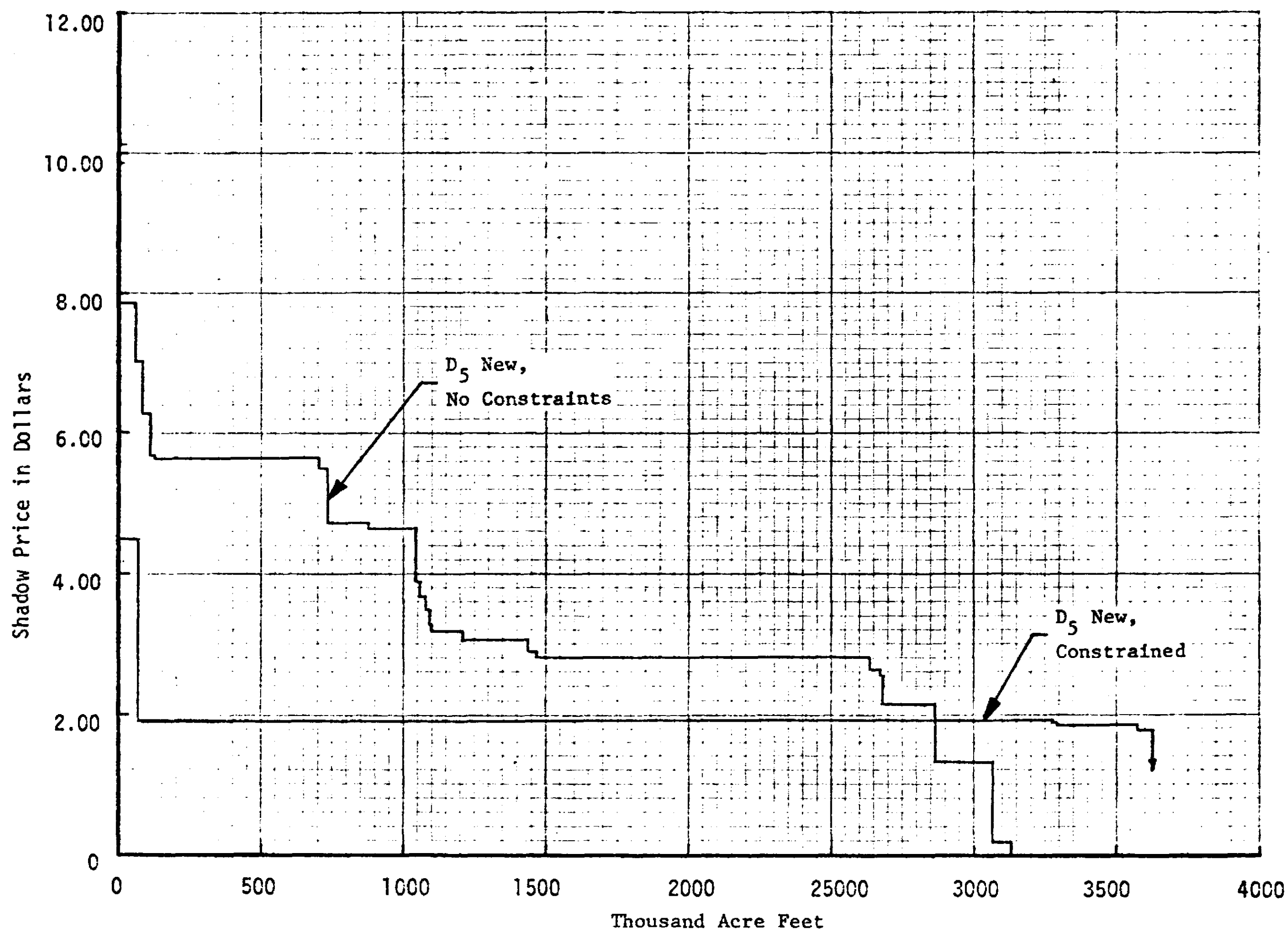

Figure 15. Demand for irrigation water on new land where development is, and is not, constrained to develop poor land with good land (Region 5 - Sevier River)

about \$22.75 to import the water from Region 4 for use in Region 5. Figures 14 and 15 indicate that the net benefit of such imports would not be great enough to pay the total cost of importation, storage, and distribution.

Region 6 (Cedar-Beaver):

This region is similar to Region 5 in that there are insufficient supplies of water presently within the region to provide for full production on all of the lands which are presently under irrigation, let alone to bring more land into production. Most portions of the region are sparsely populated and no great increases of population and industrial activity are expected by the year 2000. Presently, approximately 80,000 acres of land receive some water. It is estimated that there is an additional 836,000 acres of land which would be suited for irrigated production if it were prepared and the water provided.

The model, as shown in Figure 16, indicates that all of the water which is available for irrigated production will be used in each of the time periods. It also indicates that there is not enough water in the region to provide a full supply of water on all of the presently irrigated land. The indicated equilibrium level of water use in 1965 is indicated to be 165,000 acre-feet of water at a price of \$8.36 per acre-foot. The equilibrium level in 1980 is shown to be 161,000 acre-feet at \$8.79 per acre-foot and that for 2000 is 156,500 acre-feet at \$9.21 per acre-foot. King (1972) estimates that the actual level of water use in 1965 was 300,000 acre-feet. The difference is caused by those factors which were previously explained concerning Region 5.

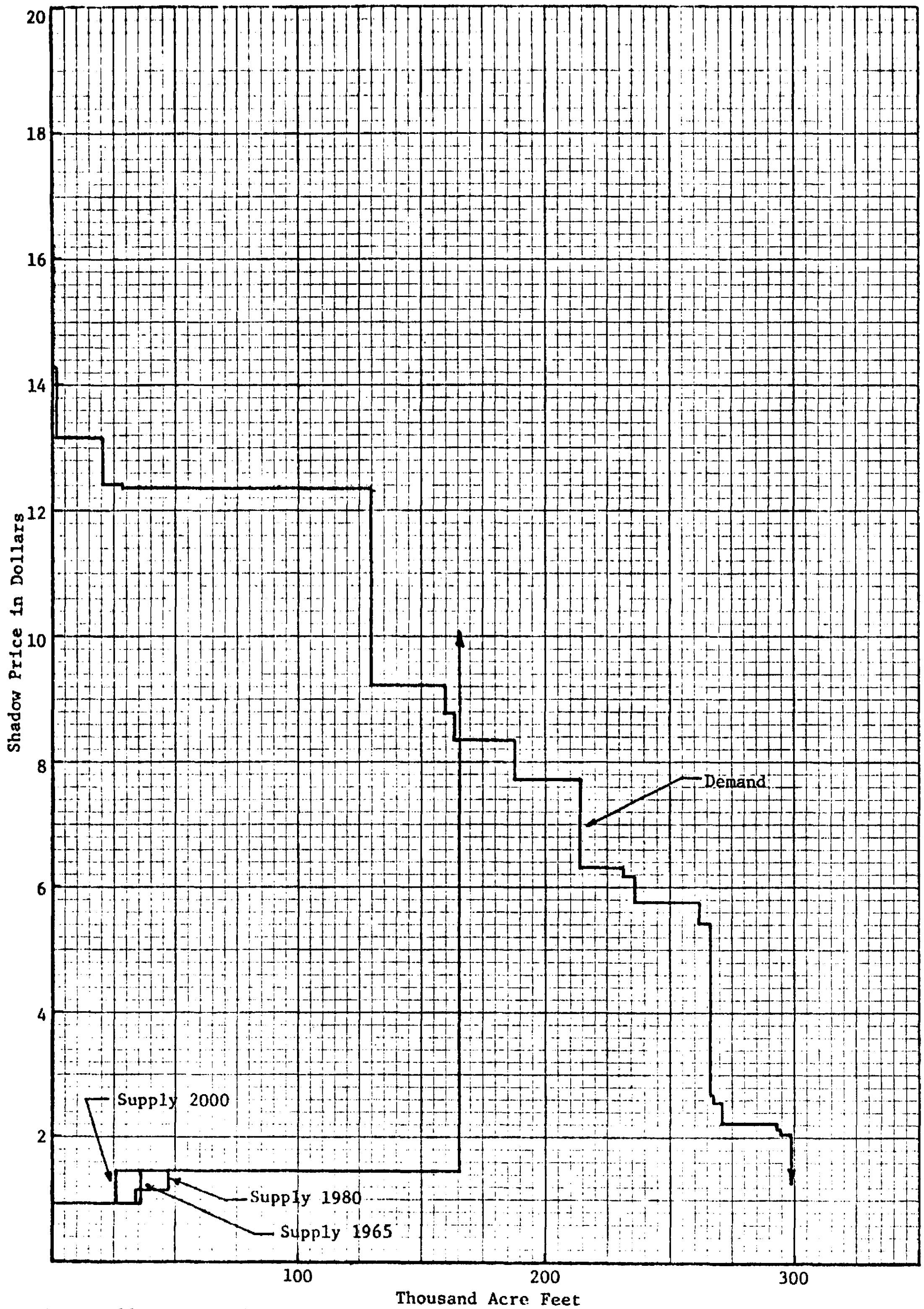

Figure 16. Demand function for water on presently irrigated land and supply functions for 1965, 1980, and 2000 (Region 6 - Cedar-Beaver)

A level of 300,000 acre-feet, as is indicated by Figure 16, would fully irrigate the land which is currently under irrigated production. However, even if the supply level, which could be maintained for long periods of time, were this high, there would be no water "left over" for use in opening new lands for irrigated production. Figure 17 depicts this situation by showing the two demand curves for irrigation water on land which presently is not irrigated. The supply curves in this case correspond with the verticle axis at a water quantity level of zero. Without water imports, this region will not, according to the model, be able to maintain full production on its presently irrigated land or open up new areas for irrigated agriculture.

The importation cost estimates from King (1972) indicate that transportation, storage, and distribution of water imported from Region 5 would be \$17.10 per acre-foot. However, since Region 5 has no surplus water, any water imported from Region 5 would first have to be transferred into that region from another part of the state which means that the actual cost would be greater than \$17.10 per acre-foot. Figures 16 and 17 clearly indicate that the marginal value product attributable to the water would probably not be sufficient to cover the total costs of importation.

Region 7 (Uintah):

Certain portions of this region have fair to good crop yields on irrigated land. However, especially in the northern portion of the region, the number of crops that can be grown are limited and the yields are reduced because of the climate. Approximately 217,800 acres of

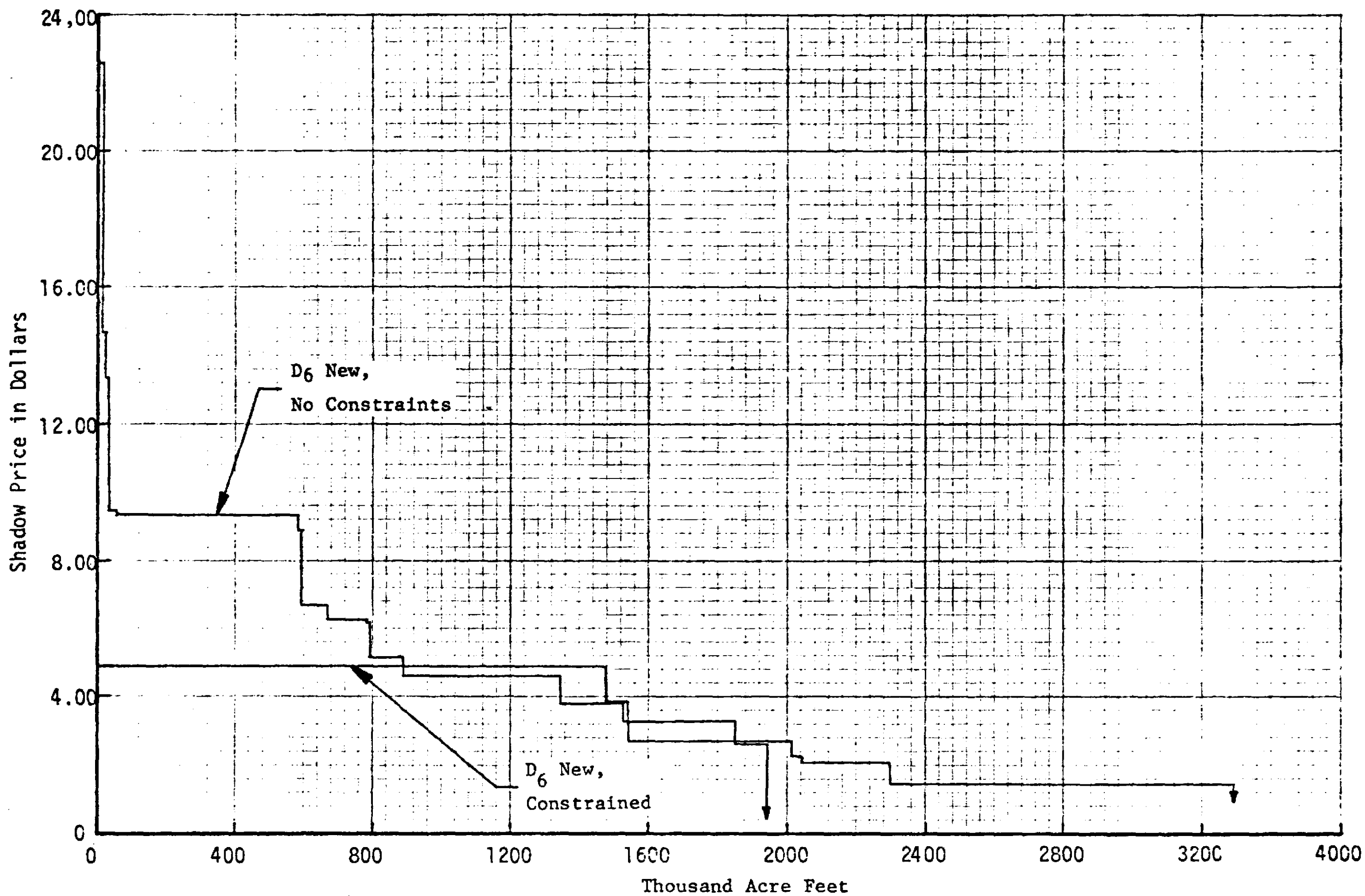

Figure 17. Demand for irrigation water on new land where development is, and is not, constrained to develop poor land with good land (Region 6 - Cedar-Beaver)

land are currently under irrigated cultivation. The region also has approximately 320,200 acres of potentially irrigable land. The area presently has some industrial development. However, this development is very limited. The area is known to contain petroleum deposits in the form of crude oil and gas under the earth's surface and in the form of oil-shale deposits. It has been projected that significant industrial growth and an increase in demands for water for municipal and industrial purposes will result as these energy sources are developed and used.

Figure 18 shows the interaction of the demand curve for irrigation water to be used on presently irrigated land with the irrigation water supply curves for the three time periods. A municipal and industrial water use level of 10,000 acre-feet was used in deriving the supply curve for irrigation water for 1965, while projected estimates of 50,000 and 104,000 acre-feet were used in estimating the supply curves for 1980 and 2000. Because of the large supply of water which is available in this region, the significant increase in municipal and industrial water use has no effect on the equilibrium level of irrigation water use in each of the three periods. At the point of equilibrium, 792,000 acre-feet of water is used in the production of crops at a price of $1.73 per acre-foot. King (1972) estimated that 789,000 acre-feet of water was the actual use level. This represents a difference of a small fraction of one percent. The model does indicate that production on some of the least productive lands might not be profitable.

Figure 19 indicates that because of the cost of preparing the land for irrigated agriculture and the low yields on some of the land,

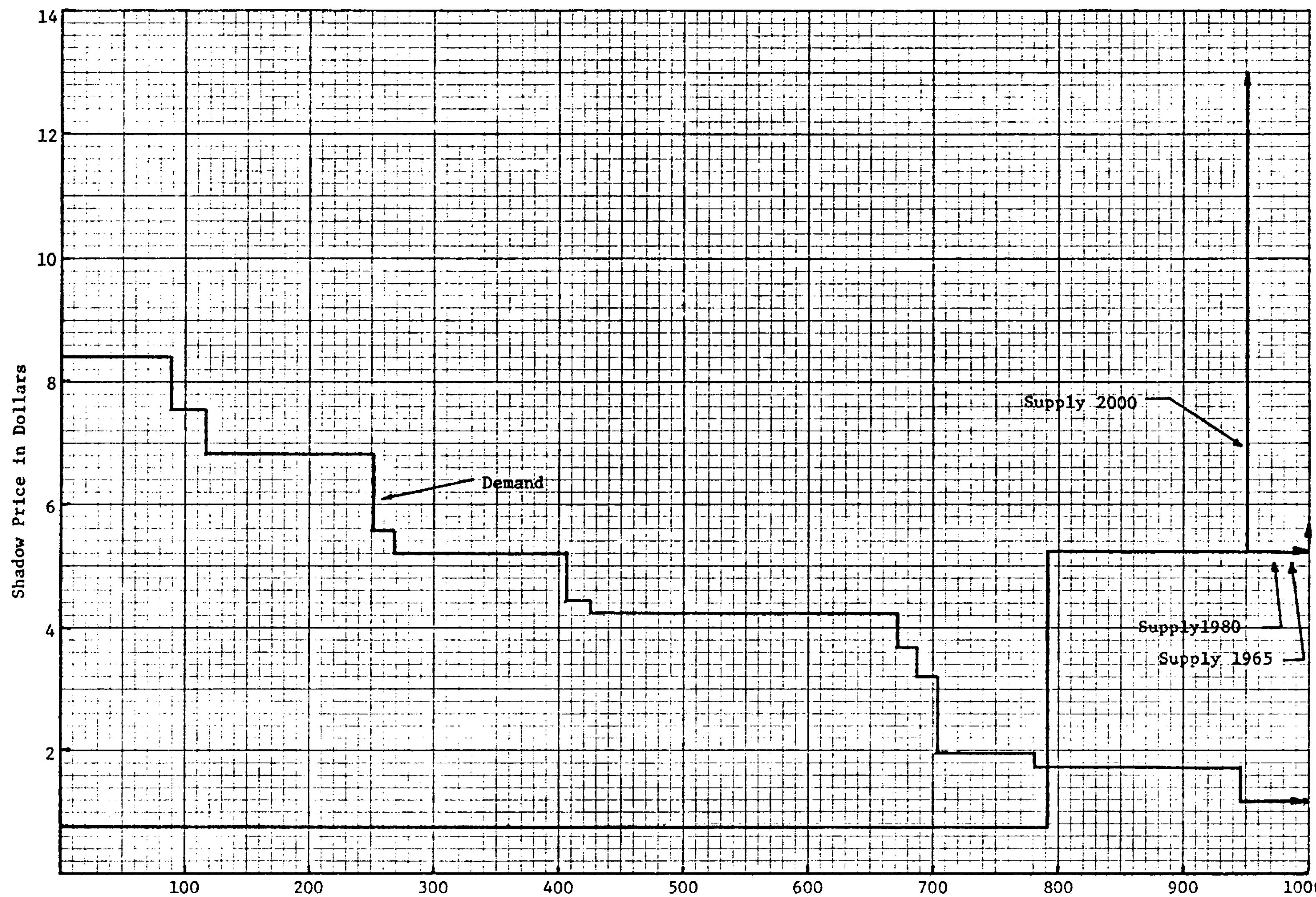

Figure 18. Demand function for water on presently irrigated land and supply functions for 1965, 1980, and 2000 (Region 7 - Uintah Basin)

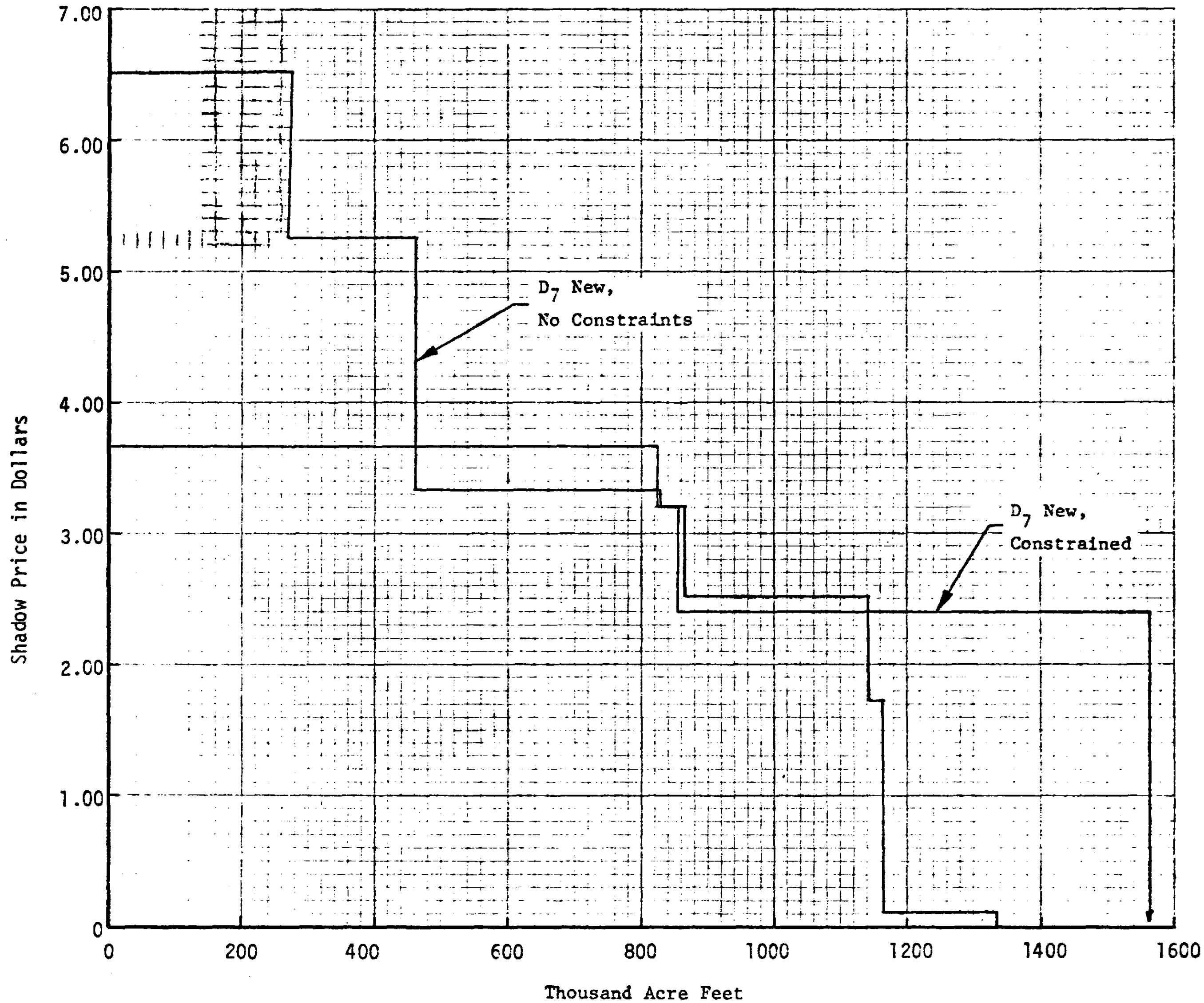

Figure 19. Demand for irrigation water on new land where development is, and is not, constrained to develop poor land with good land (Region 7 - Uintah Basin)

the marginal cost of providing the water is generally greater than the marginal value product due to the incremental unit of water. The water is available, but the marginal benefit is not great enough to warrant it's use in opening up new areas to irrigation. Only if the most productive land can be brought into production with little or no class III and IV land will the model recommend such development. Under those circumstances, the equilibrium point for 1965 is at 253,000 acre-feet of water and a price of $6.51. The price remains at $6.51 in 1980 and 2000 but the quantity drops to 208,000 acre-feet and 158,000 acre-feet, respectively. Since it is doubtful that all of the best land lies together, the model indicates that little development is recommended for the region.

Since most of the proposed water importation schemes in Utah involve exporting water from Region 7 to other portions of the state, there is no need to discuss the possibility of water importation into Region 7. Ample water is available within the region for development at a much lower cost than the cost of importing water.

Region 8 (West Colorado):

Region 8 is sparsely populated and has a low level of industrial growth. Because of the coal deposits and the many areas with a very low population level, it is expected that some growth will occur due to the production of power. However, municipal and industrial activities are not expected to become large water users. Approximately 94,900 acres of land are presently under irrigation and the region contains an additional 304,300 acres of potentially irrigable land.

Municipal and industrial water use levels of 7,000, 16,000, and 29,000 acre-feet were used in deriving the supply functions for the years 1965, 1980, and 2000, as shown in Figure 20. The small increase in M & I use seems to have no effect on the equilibrium because it remains at 303,000 acre-feet of water and a price of \$3.90 per acre-foot. This is exactly the same as the actual estimated water use level. However, given that the total use is the same, the model recommends that the water be taken off some of the less productive land and be used to supplement the water used on the better quality land.

In Figure 21, the model indicates that there may possibly be enough water available at a low enough marginal cost within the region to warrant the development of irrigation in some potentially irrigable areas. However, this result isn't certain because the supply curves represent a higher marginal cost than the value of the marginal value products on the lower demand curve (which assumes that all four land classes are brought into production together) at all water use levels. The more optimistic equilibrium levels are all at the price of \$7.11 per acre-foot and quantities of 231,000 acre-feet for 1965; 222,000 acre-feet for 1980; and 210,000 acre-feet for the year 2000. Based on these facts, it is doubtful if much new irrigation development will occur unless water is imported into the region. The water quantities at the above equilibrium points represent all of the water which is left for agricultural use after the water requirements for use on presently irrigated land have been met. The situation regarding the importation of water into the region is similar to that discussed in

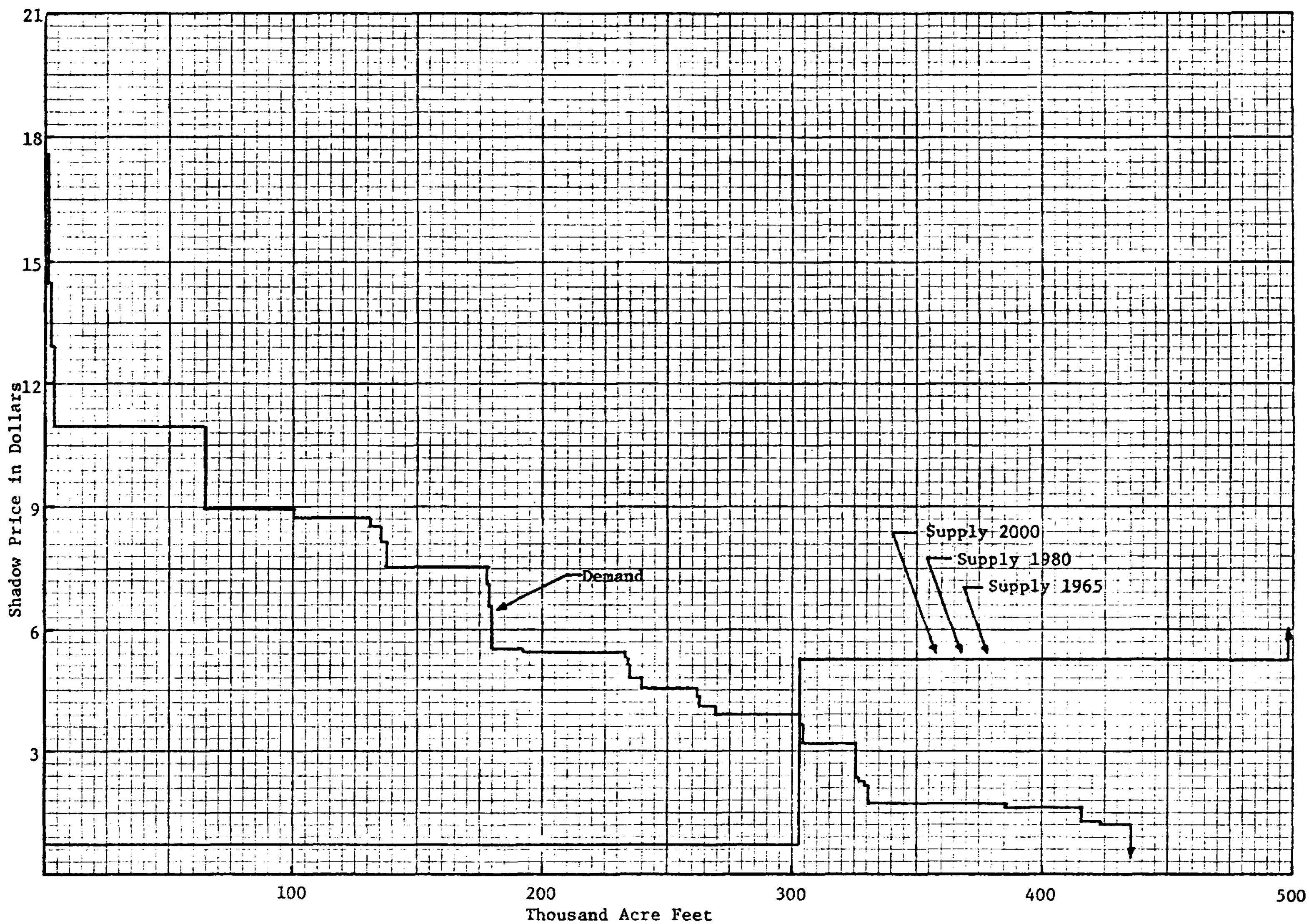

Figure 20. Demand function for water on presently irrigated land and supply functions for 1965, 1980, and 2000 (Region 8 - West Colorado)

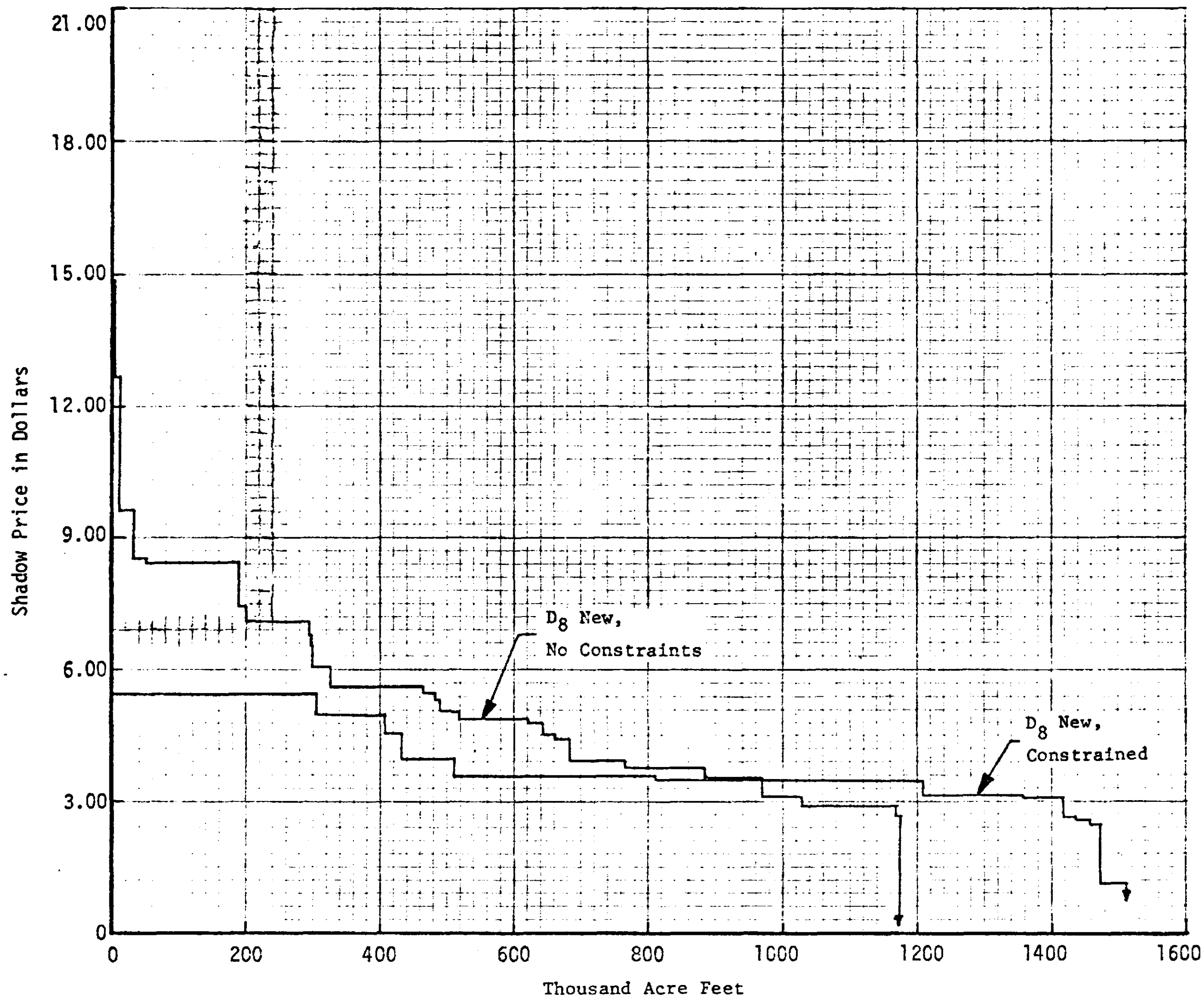

Figure 21. Demand for irrigation water on new land where development is, and is not, constrained to develop poor land with good land (Region 8 - West Colorado)

relation to the other regions in that, given our present technology, the estimated cost per acre-foot of importing the water is greater than the return per acre-foot in agriculture (King, 1972).

Region 9 (Southeast Colorado):

There has been very little industrial growth in this very dry region. The area supports a very small population and very little irrigation is practiced in the region. There are only approximately 19,000 acres of land in irrigated production, with only part of that land receiving a full water supply. A large amount of land, approximately 533,400 acres, is suitable for irrigation if the water were available at a low enough cost. A significant increase in the use of water for municipal and industrial purposes has been forecast because of the planned use of the area as a major electrical power production point.

As can be seen from Figure 22, this increase in M & I water use is not expected to affect the supply function at low levels of water use. The municipal and industrial water use levels used in the model for the three periods are 6,800 acre-feet in 1965, 38,000 acre-feet in 1980, and 79,000 acre-feet in the year 2000. The equilibrium point for water on presently irrigated land for all three periods is at a water use level of 150,000 acre-feet and a price of $1.73. Again, this is exactly equal to the estimated level of actual water use made by King (1972). However, the model again indicates that water should be taken off of the least productive land and used to supplement the supply on the higher quality land.

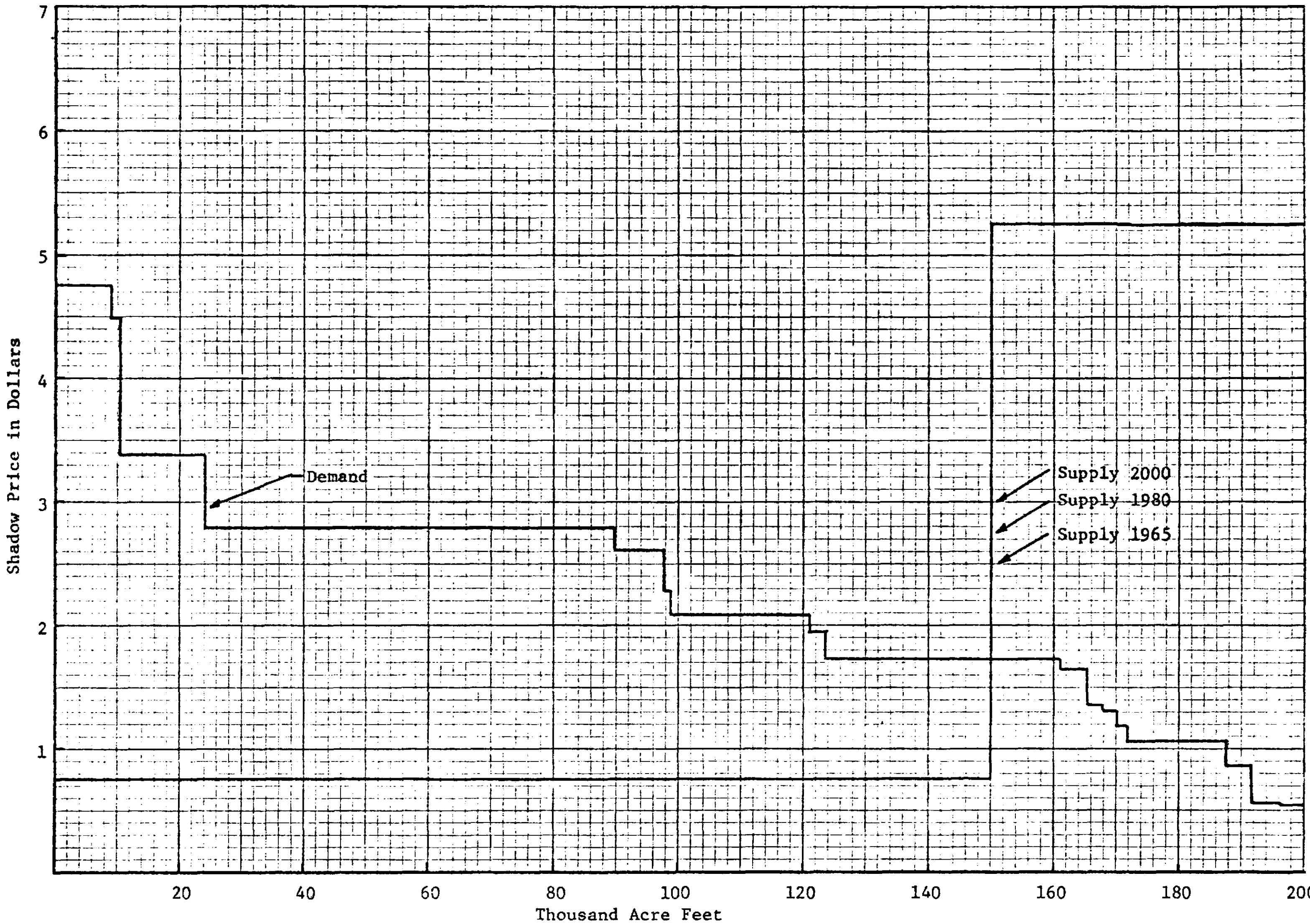

Figure 22. Demand function for water on presently irrigated land and supply functions for 1965, 1980, and 2000 (Region 9 - South and East Colorado)

Because of factors such as the cost of bringing new land into production, yield levels, etc., the marginal value productivity of water to be used on potentially irrigable land is very low. In fact, it is so low (as shown in Figure 23) that it doesn't warrant opening new areas for irrigation. The marginal value productivity is also so low that it could not alone meet the total cost of importing water.

Region 10 (Lower Colorado):

This region, located in the southwest corner of the state, has a relatively small population and little actual industry. The projected growth in population and industry represents a small absolute increase. Because of the rich soil, the warm climate, and the long growing season, the yields on much of the land are the highest in the state. For example, with an adequate supply of water, it is not uncommon for five full crops of alfalfa hay to be harvested in a season. One of the biggest problems of the area is that there is a very small water supply. Approximately 21,000 acres are presently under irrigation in the region and there are about 244,100 acres of potentially irrigable land.

The supply curves in Figure 24 are based on municipal and industrial water uses of 1,500 acre-feet in 1965, 4,000 acre-feet in 1980; and 6,000 acre-feet in 2000. Because of the small increase in M & I use, the supply curve isn't affected at the lower water use levels. The equilibrium point for all three years is at a quantity level of 116,600 acre-feet and a price of $5.25 per acre-foot. The estimate of the actual level of water use is 68,000 acre-feet. This represents a significant difference and would seem to indicate that the returns

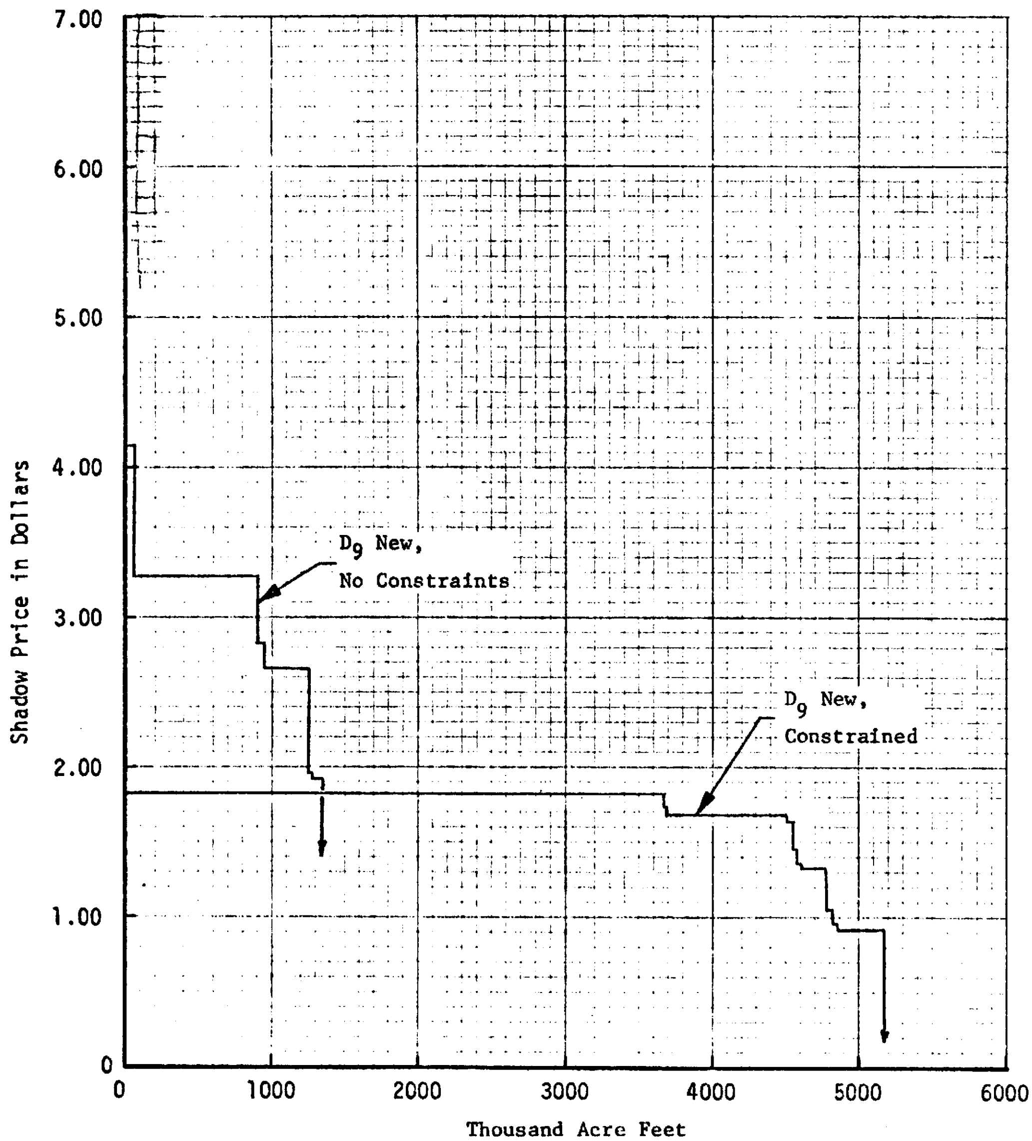

Figure 23. Demand for irrigation water on new land where development is, and is not, constrained to develop poor land with good land (Region 9 - South and East Colorado)

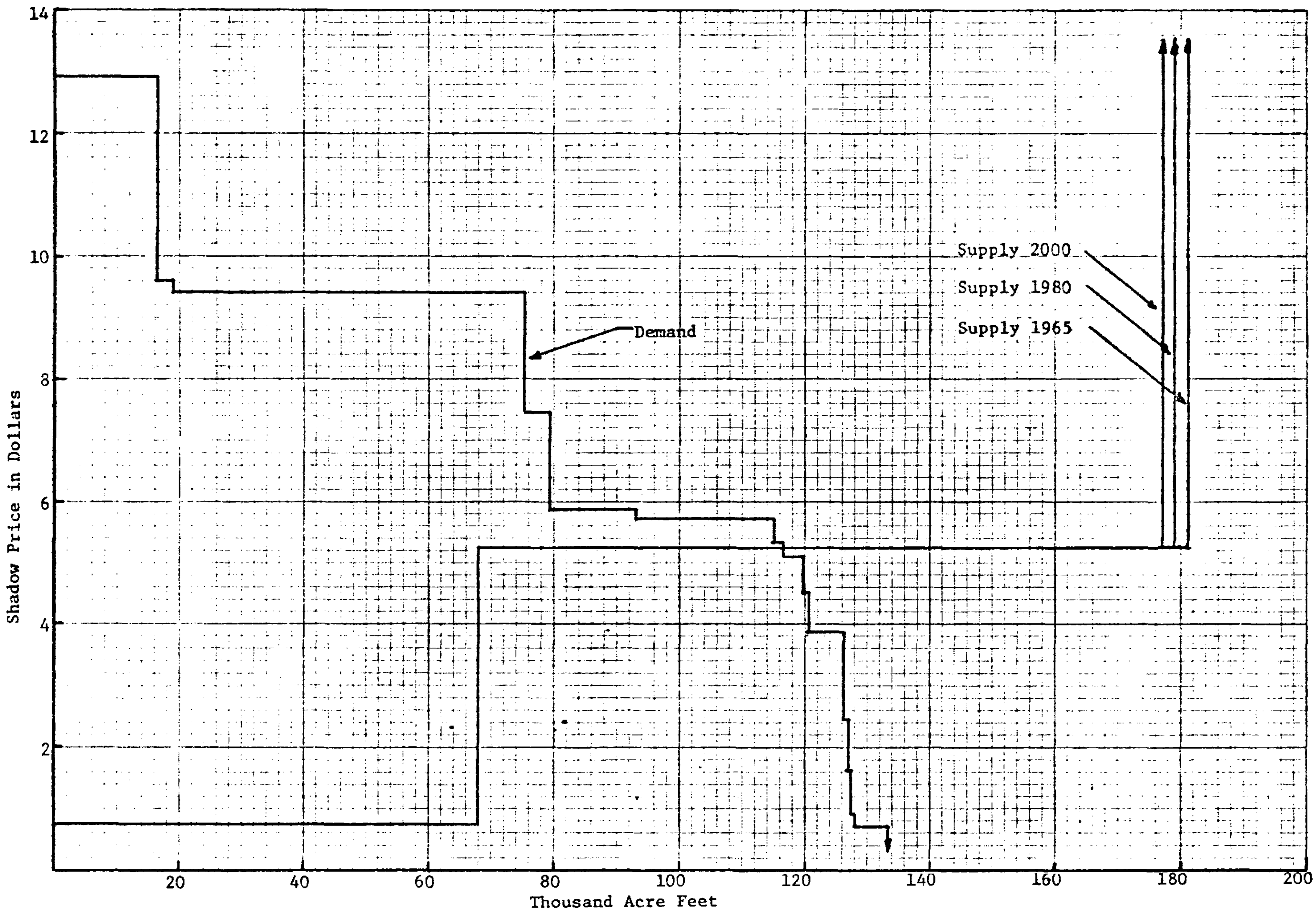

Figure 24. Demand function for water on presently irrigated land and supply functions for 1965, 1980, and 2000 (Region 10 - Lower Colorado)

would justify the application of more water to the more productive lands. The model, however, does not consider the problem of water quality. It is possible that less water is used than the optimum indicated by the model because of the problem of sedimentation which occurs in this region. If the problem is critical enough, the application of the last increments of water might lower the yields and reduce profitability. Before additional water is used, problems of water quality and timing should be considered. The model also indicates that costs and returns on the poorest lands are such that perhaps they should be removed from production, thereby releasing water for use on the more productive lands.

Figure 25 indicates that the model recommends little, if any, development of potentially irrigable lands. The marginal cost of supplying water to the potentially irrigable land is greater than the marginal value product derived from the water used at all levels when compared to the lower demand curve. The equilibrium levels, as shown by the upper demand curves' intersection with the supply curves, are all at a price of \$7.99 per acre-foot and quantities of 64,400 acre-feet, 62,400 acre-feet, and 60,400 acre-feet for the respective time periods. Like the other regions, the cost situation regarding imports is such that, given the underlying assumptions of the model, importation of water for agricultural use is probably not justified by the potential returns (King, 1972).

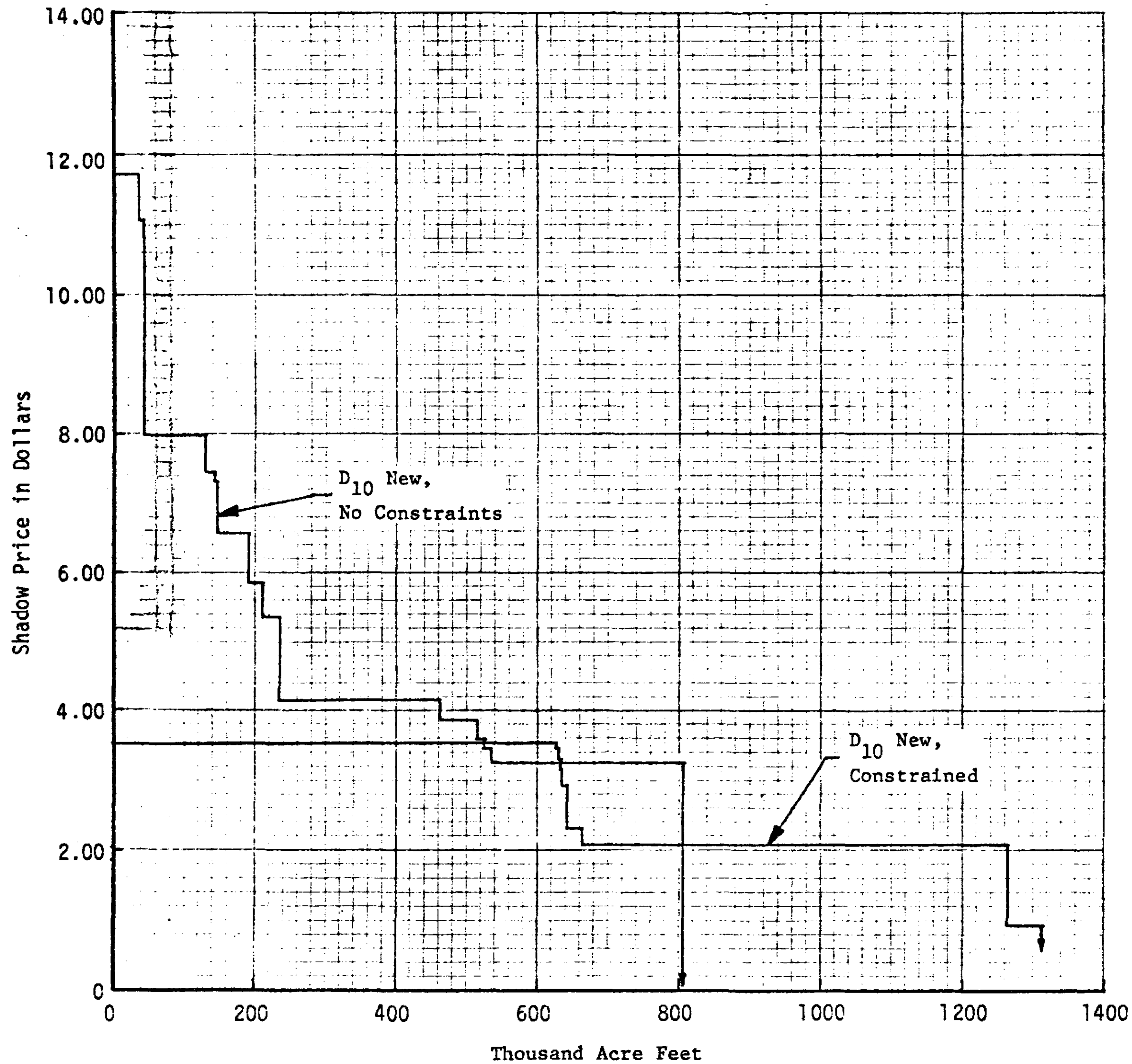

Figure 25. Demand for irrigation water on new land where development is, and is not, constrained to develop poor land with good land (Region 10 - Lower Colorado)

CONCLUSIONS

The results of the model indicate that most portions of the state suffer from a water shortage in that more production could be obtained from the presently irrigated land. Regions 2, 3, 4, and 7 appear to be the exceptions. However, even in those regions, there are individual areas or farms where more water would profitably increase the output, and there are other cases where water is used inefficiently and wasted. The best way to meet this water shortage appears to be to allow water to be transferred more freely within subregions so that some of the water presently used on marginally productive lands could be used for supplemental irrigation on the more productive soils.

The results of the analysis show that only in Regions 2 and 3 should most of the presently irrigated land remain under irrigation. In Region 7, and to a lesser degree in Region 4, the model shows that there is little need for supplemental irrigation on most of the more productive lands but that some of the poorest lands still should not be irrigated because production is not profitable. In the six other regions, the model indicates that the farming operations would probably be more profitable if water were more freely mobile within the system so that it could be transferred between agricultural uses and users of lower marginal productivity and those of higher productivity. This would enable each incremental unit of water to approximate more closely the maximum possible return for that water.

Another possible solution would be to use large scale importation of water to supplement existing subregion supplies and, possibly, to also bring more land under cultivation. Undoubtedly, there will eventually be water importation projects for some portions of the state. This model is not designed to adequately evaluate the economic feasibility of such projects. However, when the projected costs of importing water into each of the hydrologic subregions are considered in relation to the marginal value product of the water on both presently irrigated (for supplemental irrigation) and potentially irrigable land in those subregions, it appears that agriculture alone cannot justify or finance such importation at this time. Many factors, such as market changes and technological advancements, could occur in the future which would enhance the desirability of such water transportation schemes.

If water importation costs are assumed to be roughly equal for all regions, and if water importations are deemed desirable, based on the marginal value product levels developed by the model, Regions 5 and 6 seem to have the greatest demand for more water to be used on presently irrigated land for supplemental irrigation. If the intent is to open new lands to irrigation, it is difficult to isolate two or three areas that show the most promise, based on the marginal value productivity schedules. Some of the regions have very high marginal value product levels at the top of the demand curve; however, these high values drop very rapidly as more water is applied. Since water application levels as small as those dictated by the extremely high marginal value product levels are not practical, the important question concerns the value of the water at greater water use levels.

Some of the regions have much lower high points on their marginal value product scales, but drop in value at a slower rate. Therefore, the region with the lower top value may be just as likely to receive water for development purposes as the area with the higher maximum curve.

Region 9 is clearly less likely to be able to adequately support water importation than any of the other areas because of the extremely low marginal value product levels. Importation is also unrealistic for Region 7 because such large water supplies are located there. Although Region 1 has a moderately high marginal value product curve, physical as well as economic barriers may block large scale importation. Many of the areas which appear to be the most realistic for further development are also the areas which presently have the most adequate water supplies. (Regions 2, 3, and 4.) However, especially in Region 3, and to a lesser extent in Region 4, there is little land available for such development, and M & I uses will remove much of the agricultural land from irrigated production, as well as reduce the potentially irrigable acreages. Region 5 may have some potential for importation for development purposes, but only if reasonably large tracts of land which include a very low proportion of the poorer yielding land can be developed. Regions 6, 8, and 10 apparently could provide for agricultural expansion, especially if large tracts of high quality land could be developed.

The elasticity of demand for agricultural products is such that a given increase in output tends to lead to an even greater percentage decrease in price. This means that the total income of all farmers as a group may decline as output increases. Due to the highly inelastic nature of the demand for agricultural output, before any large scale water importation schemes are started, they should be studied to see how the increases in output will affect farmers' income. The regional as well as the national impact should be considered, because any price and income effects of such development would be more likely to be felt within the intermountain area than elsewhere.

LIMITATIONS OF THE STUDY

It is difficult to evaluate the data relating to the inputs and outputs used in models such as those developed for each of Utah's ten hydrologic subregions. The data collection problems of the demand portion of the models are especially formidable (Gardner, 1966; Dawson, 1957; and Anderson, 1972). Obviously, if the input information in the model is incorrect, it could bias the results. The information that was used was considered to be the best available; however, it would be impossible for all of the input data to be exactly correct.

The assumptions which underlie the demand and supply models may also have an effect on the validity of the supply and demand functions which are derived. The underlying assumptions were made to mirror the "real world" as much as possible. However, there are some simplifying assumptions (e.g., the method of aggregation which was used in the demand models) which were necessary to make the research project technically and economically feasible.

Demand curves were estimated for 1980 in each region. These demand curves were then combined with different supply curves to represent the conditions in 1965, 1980, and the year 2000. It would be prohibitively expensive to estimate demand schedules for each of these points in time. The assumption has been made that the cost of inputs per acre in real terms in 1980 and in 2000 will remain at approximately the present level. The use of farm labor is predicted to decline but it is expected that this decline will be roughly offset by an increase in the use of capital. Yields, prices, and other inputs are estimated with the assumption that increased yields are projected with constant costs. The prices which are used are "normalized" prices. This helps eliminate the annual random price effects and makes the model more applicable to the time period which is covered.

Because the agricultural industry is probably the most truly competitive of all the major industries in the U. S. and because of the elasticity of demand for agricultural goods at the farm level, any economic profits which might accrue tend to be competed away or lost due to price changes for farm-produced goods. Traditionally in agriculture, as productivity increases, the price for the farm product decreases, largely erasing any possibilities for increased profits per unit. Much of the increase in farmers' incomes is due to the fact that the typical farmer now controls more resources than was the case in the past rather than because of an increase in output per unit of input. Projections for the future indicate that the trend for real farm prices to decrease as farm output increases will continue. In short, relative values are more important than absolute levels. What is significant is the change of one value relative to another. It is assumed that over time, as yields increase or as prices for farm goods increase, the prospective increases in farmers' incomes will be mostly offset by lower prices for farm goods or by increases in the prices farmers pay for their inputs. This being the case, the demand curve for irrigation water, over time, will remain relatively constant because the relationship between the cost of production and value of output per acre will remain relatively constant. (See Gisser, 1970; Heady and Ball, 1965; Heady and Tweeten, 1963; and Anderson, 1972)

The demand functions which are derived for each region are aggregate functions. The best aggregate demand function for water would be derived by estimating a demand function for each farm in each region and then by aggregating these demand functions. However, such an approach would be extremely expensive, time consuming, and unnecessary if enough similarity existed to justify the grouping of these farms. According to Miller's Theorem, such grouping is possible with a minimum amount of bias if the individual farms involved have identical input-output coefficient matrices, and if each of the farms have qualitatively homogeneous output vectors (Miller, 1966). In this study, the output or yields were found to be quite consistent among farms in each county according to land class, and the production techniques were found to be very much alike throughout the state, and that within the individual hydrologic subregions the output is extremely homogeneous (Davis, Christensen, and Richards, 1972; U.S. Department of Commerce, Bureau of the Census, 1964 and 1969). This being the case, both of the requirements of Miller's Theorem have been approximately met in the hydrologic subregions used in this study and the farms may be grouped with a minimum of bias due to aggregation.

It is conceded that the accuracy of some of the estimated inputs and assumptions may be questioned. However, the more "optimistic" estimates (those that would tend to increase the value of water) were used whenever evidence was available that tended to substantiate them. It is, therefore, likely that any errors which were made would be to over-value the water.

Another shortcoming of the model is that it does not consider the effect of seasonal shortages or surpluses of water on the value of the water. The marginal value product of water could be much higher than that shown by the demand model during a very dry, critical portion of the growing season. The M V P could also be lower during a period of excess supply.

Also, the model does not consider the effect that water quality may have on yields. It is likely that a detrimental effect would only be found in areas of chronic water shortage where water might be repeatedly recycled. Even in those regions, the negative impact would be limited to the lands at the bottom of the use pattern.

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APPENDIXES

APPENDIX A

Table 8. Costs of productions, water requirements, and yields of crops by county and region for Utah.

	Alfalfa		Alfalfa–Full							Alfalfa–Partial						
	Cost (dollars)	Labor (hours)	Yield (t) I	II	III	IV	Irr. Req.	Irr. Hrs.	Cut-tings	Yield(t) I	II	III	IV	Irr. Req.	Irr. Hrs.	Cut-tings
Region I.																
Subregion																
Beaver	10.4	.4		3.6	3.0	2.4	2.1	4.75	2		2.3	1.9	1.4	1.1	2.5	1
Tooele Central	10.4	.4	4.3	3.9	3.3	2.5	2.0	4.0	3	3.3	2.8	2.4	1.9	1.5	3.25	2
Millard West	10.4	.4		4.0	3.4	2.5	2.5	5.5	3		3.1	2.6	1.9	1.9	4.0	2
Box Elder West	10.4	.4	4.8	4.2	3.4	2.5	1.9	4.0	3	3.7	3.2	2.6	1.9	1.4	3.25	2
Tooele East	10.4	.4	4.3	3.9	3.3	2.5	2.2	4.75	3	3.3	2.8	2.4	1.9	1.5	3.25	2
Juab West	10.4	.4		3.7	3.1	2.4	1.5	3.25	2		2.1	1.8	1.4	.7	1.75	1
Region II.																
Subregion:																
Box Elder East	10.4	.4	5.2	4.6	3.6	2.5	1.9	4.0	3	4.0	3.5	2.8	1.9	1.3	3.25	2
Rich	10.4	.4			2.4	1.8	1.3	3.25	2			1.6	1.0	.6	1.75	1
Cache	10.4	.4	4.9	4.3	3.5	2.5	1.3	3.25	3	3.8	3.3	2.7	1.9	.9	2.5	2
Region III.																
Subregion:																
Morgan	10.1	.4		4.1	3.4	2.4	1.4	3.25	2.5		2.7	2.3	1.6	.9	2.5	1.5
Summit	10.1	.4			3.1	2.2	1.0	2.5	2			1.8	1.3	.2	1.0	1
Weber	11.0	.4	5.3	4.7	3.7	2.5	1.9	4.0	3	4.1	3.6	2.8	1.9	1.3	3.25	2
Davis	11.0	.4	5.3	4.7	3.7	2.5	1.9	4.0	3	4.1	3.6	2.8	1.9	1.3	3.25	2
Region IV.																
Subregion:																
Salt Lake	11.0	.4	5.4	4.7	3.7	2.5	2.2	4.75	3	4.2	3.6	2.8	1.9	1.6	3.25	2
Utah	11.0	.4	5.3	4.7	3.7	2.5	2	4.0	3	4.1	3.6	2.8	1.9	1.4	3.25	2
Northern Juab	11.0	.4		4.1	3.5	2.5	2.3	4.75	3		3.0	2.5	1.9	1.1	2.5	2
Wasatch	11.0	.4			3.4	2.4	1.1	2.5	2				1.4	.4	1.0	1
Region V.																
Subregion:																
Juab East	10.5	.4		3.6	3.0	2.4	1.9	4.0	2		2.1	1.7	1.4	1.4	3.25	1
Piute	10.5	.4		4.0	3.3	2.4	1.9	4.0	2		2.1	1.8	1.4	.9	2.5	1
Sevier	10.5	.4		4.4	3.6	2.5	2.1	4.75	3		3.4	2.8	1.9	1.6	3.25	2
Garfield West	10.5	.4		3.7	3.2	2.4	1.2	2.5	2		2.1	1.8	1.4	.5	1.75	1
Millard East	10.5	.4		4.2	3.5	2.5	2.3	4.75	3		3.2	2.7	1.9	1.7	4.0	2
Sanpete	10.5	.4		4.2	3.5	2.5	2.0	4.0	2.5		3.2	2.3	1.7	1.5	3.25	1.5
Juab Central	10.5	.4		3.6	3.0	2.4	2.5	5.5	2		2.1	1.7	1.4	1.3	3.25	1.0
Region VI.																
Subregion:																
Iron	11.0	.4	4.9	4.3	3.5	2.5	2.0	4.0	3	3.8	3.3	2.7	1.9	1.5	3.25	2
Beaver Central	11.0	.4		4.0	3.3	2.4	2.1	4.75	2		2.5	2.0	1.4	1.1	2.5	1
Beaver East	11.0	.4		4.0	3.3	2.4	1.6	3.25	2		2.5	2.0	1.4	.8	1.75	1
Millard South	11.0	.4		4.3	3.5	2.5	2.3	4.75	3		3.3	2.7	1.9	1.7	4.0	2
Region VII.																
Subregion:																
Uintah	9.7	.3		3.6	3.0	2.4	2.1	4.75	2		2.1	1.7	1.4	1.1	2.5	1
Duchesne	9.7	.3		3.6	3.0	2.4	2.2	4.75	2		2.1	1.7	1.4	1.2	2.5	1
Daggett	9.7	.3			2.1	1.3	1.6	3.25	1			4.8*	3.0*	.7	1.75	0
Region VIII.																
Subregion:																
Garfield East	11.0	.4		3.7	3.2	2.4	1.7	4.0	2		2.1	1.8	1.4	.8	1.75	1
Wayne	11.0	.4	4.5	3.9	3.4	2.4	1.4	3.25	3	3.5	3.0	2.6	1.8	.7	1.75	2
Carbon	11.0	.4		4.4	3.6	2.5	2.3	4.75	3		3.4	2.8	1.9	1.7	4.0	2
Grand West	11.0	.4	5.0	4.4	3.6	2.5	2.7	5.5	3	3.9	3.4	2.8	1.9	2.0	4.0	2
Emery	11.0	.4	4.8	4.1	3.6	2.5	2.0	4.0	3	3.7	3.2	2.8	1.9	1.0	2.5	2
Region IX.																
Subregion:																
Grand ~~West~~ East	10.5	.4	5.0	4.4	3.6	2.5	2.8	5.5	3	3.9	3.4	2.8	1.9	2.1	4.75	2
San Juan	10.5	.4		3.9	3.3	2.4	1.9	4.0	2		2.3	2.0	1.4	.9	2.5	1
Kane East	10.5	.4		3.7	3.2	2.4	2.6	5.5	2		2.1	1.8	1.4	1.2	2.5	1
Region X.																
Subregion:																
Washington	11.1	.4	7.3	6.1	4.8	3.0	3.8	7.75	5	4.9	4.1	3.2	2.3	3.2	5.25	3.5
Kane West	10.5	.4		3.9	3.4	2.5	2.6	5.5	2.5		2.6	2.1	1.6	1.2	2.5	1.5

Table 8. (Continued).

	Barley Cost (dollars)	Barley Labor (hours)	Barley Yield (bushels) I	II	III	IV	Barley Irrigation Requirement (acre-feet)	Barley Irrigation Hours	Nurse Crop Cost (dollars)	Nurse Crop Labor (hours)	Nurse Crop Yield (bushels) I	II	III	IV	Nurse Crop Irrigation Requirement (acre-feet)	Nurse Crop Irrigation Hours
Region I.																
Subregion:																
Beaver	35.1	2.7		68	55	44	1.2	3.25	41.4	3.1		50	39	30	1.7	4.0
Tooele Central	35.1	2.7	90	72	60	46	1.1	3.25	41.4	3.1	70	54	44	32	1.6	3.25
Millard West	35.1	2.7		70	58	46	1.4	4.0	41.4	3.1		52	42	32	2.0	4.0
Box Elder West	35.1	2.7	92	79	66	48	1.0	3.25	41.4	3.1	72	61	50	34	1.5	3.25
Tooele East	35.1	2.7	90	72	60	46	1.4	4.0	41.4	3.1	70	54	44	32	1.6	3.25
Joab West	35.1	2.7		70	58	46	0.9	2.50	41.4	3.1		52	42	32	1.2	2.5
Region II.																
Subregion:																
Box Elder East	35.2	2.7	96	84	70	50	0.8	2.5	41.4	3.1	76	66	54	36	1.4	3.25
Rich	35.2	2.7			54	42	0.8	2.5	36.8	2.7			38	30	1.0	2.5
Cache	35.2	2.7	90	78	65	48	0.6	1.75	41.4	3.1	70	60	49	34	1.0	2.5
Region III.																
Subregion:																
Morgan	35.7	2.7		78	65	46	0.7	2.5	34.3	2.5		60	52	32	1.0	2.5
Summit	35.7	2.7			60	44	0.5	1.75	37.3	2.5			44	30	0.8	1.75
Weber	35.7	2.7	96	84	70	50	0.8	2.50	41.4	3.1	76	66	54	36	1.3	3.25
Davis	35.7	2.7	96	84	70	50	0.7	2.5	41.4	3.1	76	66	54	36	1.3	3.25
Region IV.																
Subregion:																
Salt Lake	35.7	2.7	96	84	70	50	0.9	2.5	41.9	3.1	76	66	54	36	1.6	3.25
Utah	35.7	2.7	96	84	70	50	1.0	3.25	41.9	3.1	76	66	54	36	1.5	3.25
Northern Juab	35.7	2.7		74	62	46	1.1	3.25	41.9	3.0		56	46	32	1.7	4.
Wasatch	35.7	2.7			60	46	0.6	1.75	34.9	1.7			44	32	0.8	1.75
Region V.																
Subregion:																
Juab East	35.7	2.7		68	58	46	.9	2.5	41.4	3.1		50	42	32	2.0	4.
Piute	35.7	2.7		65	54	42	1.0	3.25	41.4	3.1		47	38	30	1.5	3.25
Sevier	35.7	2.7		80	66	48	1.2	3.25	41.4	3.1		62	50	34	1.7	4.
Garfield West	35.7	2.7		65	54	42	0.7	2.50	41.4	3.1		47	38	28	1.0	2.5
Millard East	35.7	2.7		72	60	48	1.0	3.25	41.4	3.1		54	44	34	1.9	4.
Sanpete	35.7	2.7		70	58	47	1.1	3.25	41.4	3.1		52	42	33	1.5	3.25
Juab Central	35.7	2.7		68	58	46	1.6	4.75	41.4	3.1		50	42	32	1.4	3.25
Region VI.																
Subregion:																
Iron	35.7	2.7	88	74	62	48	1.0	3.25	41.4	3.1	68	56	46	34	1.5	3.25
Beaver Central	35.7	2.7		72	60	48	1.2	3.25	41.4	3.1		54	44	34	1.7	4.
Beaver East	35.4	2.7		72	60	48	0.9	2.50	41.4	3.1		54	44	34	1.3	3.25
Millard South	35.4	2.7		72	60	48	1.0	3.25	41.4	3.1		54	44	34	1.7	4.
Region VII.																
Subregion:																
Uintah	35.2	2.7		72	59	46	1.2	3.25	37.3	2.8		54	43	32	1.6	3.25
Duchesne	35.2	2.7		68	55	44	1.3	4.0	37.3	2.8		50	39	30	1.6	3.25
Daggett									36.8	2.7			38	30	1.2	2.5
Region VIII.																
Subregion:																
Garfield East	35.6	2.7		65	54	42	0.9	2.50	41.4	3.1		47	38	30	1.3	3.25
Wayne	35.6	2.7	84	72	60	46	1.0	3.25	41.4	3.1	64	54	44	32	1.2	2.50
Carbon	35.6	2.7		74	62	47	1.2	3.25	41.4	3.1		56	46	33	1.8	4.
Grand West	35.6	2.7	90	74	62	47	1.4	4.	41.4	3.1	70	56	46	33	2.0	4.
Emery	35.6	2.7	86	73	61	46	1.2	3.25	41.4	3.1	66	55	45	32	1.6	3.25
Region IX.																
Subregion:																
Grand East	34.6	2.7	90	74	62	47	1.4	4.	41.0	3.1	70	56	46	33	2.1	4.75
San Juan	34.6	2.7		69	56	45	1.3	4.	41.0	3.1		51	40	31	1.6	3.25
Kane East	34.6	2.7		65	54	42	1.4	4.	41.0	3.1		47	38	30	2.0	4.
Region X.																
Subregion:																
Washington	35.7	2.7	96	82	68	49	1.5	4.	41.9	3.1	76	64	52	35	2.0	4.0
Kane West	35.7	2.7		70	58	46	1.1	3.25	41.4	3.1		52	42	32	1.8	4.0

Table 8. (Continued).	Corn							Sugar Beets						
	Cost (dollars)	Labor (hours)	Yield(t) I	II	III	Irrigation Requirement (acre-feet)	Irrigation Hours	Cost (dollars)	Labor (hours)	I	II	III	Irrigation Requirement (acre-feet)	Irrigation Hours
Region I.														
Subregion:														
Beaver														
Tooele														
Millard West	48.9	4.8		19.3	15.8	1.7	5.5							
Box Elder	48.9	4.8	22.0	19.4	15.8	1.2	4.5							
Tooele East														
Juab West														
Region II.														
Subregion:														
Box Elder East	50.4	4.8	23.5	20.4	17.0	1.2	4.5	89.9	25.0	21.0	19.0	16.5	1.6	9
Rich														
Cache	50.4	4.8	22.5	19.9	16.0	.7	2.5	89.9	25.0	20.0	18.0	15.3	1.2	7
Region III.														
Subregion:														
Morgan														
Summit														
Weber	52.8	5.0	23.5	20.3	17.0	1.1	3.5	89.9	25.0	22.6	20.3	17.0	1.6	9
Davis	52.8	5.0	23.5	20.4	17.0	1.1	3.5	89.9	25.0	22.6	20.3	17.0	1.6	9
Region IV.														
Subregion:														
Salt Lake	52.8	5.0	23.5	20.3	17.0	1.4	4.5	89.9	25.0	22.6	20.3	17.0	1.9	10
Utah	52.8	5.0	23.5	20.3	17.0	1.4	4.5	89.9	25.0	21.0	19.0	16.5	1.7	9
Northern Juab														
Wasatch														
Region V.														
Subregion:														
Juab East														
Piute														
Sevier	49.2	5.1		20.4	17.0	1.4	4.5							
Garfield West														
Millard East	49.2	5.1		19.5	16.0	1.5	4.5							
Sanpete	49.2	5.1		19.5	16.0	1.3	4.5							
Juab Central														
Region VI.														
Subregion:														
Iron	48.0	4.5		20.0	19.7	1.3	4.5							
Beaver Central														
Beaver East														
Millard South	48.0	4.5		19.5	16.0	1.5	4.5							
Region VII.														
Subregion:														
Uintah	49.2	5.1		20.0	17.0	1.4	4.5							
Duchesne	49.2	5.1		18.0	14.5	1.5	4.5							
Region VIII.														
Subregion:														
Garfield East														
Wayne														
Carbon	48.6	4.6		19.8	16.2	1.5	4.5							
Grand West	48.6	4.6	21.0	19.2	16.0	1.8	5.5							
Emery	48.6	4.6	20.5	18.5	15.3	1.3	4.5							
Region IX.														
Grand East	48.6	4.6	21.0	19.2	16.0	1.9	5.5							
San Juan														
Kane East														
Region X.														
Subregion:														
Washington	53.4	5.3	30.0	26.9	22.0	2.3	6.5							
Kane West														

Table 8. (Continued).

	Pasture					Wheat		
	Cost (dollars)	Labor (hours)	Yield (AUM)	Consumptive Irrigation Requirement (acre-feet)	(W/hours)	Cost (dollars)	Labor (hours)	Yield (bushels)
Region I.	9.8	.6	7.1	1.9	5.5			
Subregion:								
Beaver	9.8	.6	7.1	1.9	5.5			
Tooele Central	9.8	.6	7.1	1.8	4.75			
Millard West	9.8	.6	7.1	2.2	6.25			
Box Elder West	9.8	.6	7.1	1.6	4.75	8.2	.5	11
Tooele East	9.8	.6	7.1	1.8	4.75	8.2	.5	10
Juab West	9.8	.6	7.1	1.4	4.0			
Region II.								
Subregion:								
Box Elder East	9.8	.6	7.1	1.6	4.75	8.2	.5	11
Rich	8.8	.5	5.0	1.1	3.25	8.2	.5	9
Cache	9.8	.6	7.1	1.1	3.25	8.2	.5	11
Region III.								
Subregion:								
Morgan	10.0	.7	6.8	1.2	3.25	8.2	.5	11
Summit	10.0	.7	6.2	.8	2.5			
Weber	10.6	.8	7.1	1.6	4.75	8.2	.5	11
Davis	10.6	.8	7.1	1.6	4.75	8.2	.5	11
Region IV.								
Subregion:								
Salt Lake	10.6	.7	7.1	1.8	4.75	8.2	.5	11
Utah	10.6	.7	7.1	1.7	4.75	8.2	.5	11
Northern Juab	10.6	.7	7.1	2.0	5.5	8.2	.5	10
Wasatch	10.0	.7	6.8	1.0	3.2			
Region V.								
Subregion:								
Juab East	9.8	.6	6.8	1.7	4.75			
Piute	9.8	.6	6.8	1.7	4.75			
Sevier	9.8	.6	7.1	1.9	5.5			
Garfield West	9.8	.6	6.8	1.2	3.25			
Millard East	9.8	.6	7.1	2.0	5.5	8.2	.5	8
Sanpete	9.8	.6	7.1	1.7	4.75	8.2	.5	10
Juab Central	9.8	.6	6.8	2.4	6.25	8.2	.5	10
Region VI.								
Subregion:								
Iron	9.8	.6	7.1	1.7	4.75			
Beaver Central	9.8	.6	6.8	1.9	5.5			
Beaver East	9.8	.6	6.8	1.4	4.0			
Millard South	9.8	.6	7.1	2.0	5.5			
Region VII.								
Subregion:								
Uintah	9.8	.6	6.8	1.8	4.75	8.2	.5	11
Duchesne	9.8	.6	6.8	1.9	5.5			
Daggett	4.9	.3	3.9	1.4	4.0			
Region VIII.								
Subregion:								
Garfield East	9.8	.6	6.8	1.5	4.0			
Wayne	9.8	.6	6.8	1.3	4.0			
Carbon	9.8	.6	7.1	2.0	5.5			
Grand West	9.8	.6	7.1	2.2	6.25			
Emery	9.8	.6	7.1	1.7	4.75			
Region IX.								
Subregion:								
Grand East	9.2	.8	7.1	2.4	6.25			
San Juan	9.2	.8	6.8	2.0	5.5			
Kane East	9.2	.8	6.8	2.5	7			
Region X.								
Subregion:								
Washington	10.0	.7	8.6	3.2	8.5	9.3	.6	11
Kane West	9.6	.5	7.1	2.1	5.5			

APPENDIX B

Table 9Ai. Demand for irrigation water on presently irrigated land (Region 1 - Great Salt Lake Desert).

Water Diverted		Water Consumed		Acres Irrigated		Acre-Feet Per Acre	
Amount Thousand Acre-Feet	Price Dollars	Amount Thousand Acre-Feet	Price Dollars	Old Land Thousand Acres	New Land Thousand Acres	Diverted Acre Feet	Consumed Acre Feet
180.1	1.25	85.7	2.63	45.0	.	4.0	1.9
179.6	1.73	85.5	3.63	44.9	.	4.0	1.9
169.9	2.09	80.9	4.39	42.6	.	4.0	1.9
169.5	2.24	80.7	4.71	42.6	.	4.0	1.9
163.8	2.35	77.9	4.94	41.1	.	4.0	1.9
156.4	2.54	74.4	5.33	41.1	.	3.8	1.8
153.2	2.70	72.9	5.68	40.2	.	3.8	1.8
151.9	3.19	72.3	6.71	40.2	.	3.8	1.8
151.0	3.44	71.8	7.22	40.2	.	3.8	1.8
146.5	3.93	69.7	8.26	40.2	.	3.6	1.8
145.9	3.97	69.4	8.35	40.0	.	3.6	1.7
143.2	4.76	68.1	10.00	40.0	.	3.6	1.7
142.3	4.88	67.7	10.25	40.0	.	3.6	1.7
139.7	5.04	66.5	10.60	40.0	.	3.5	1.7
137.4	5.24	65.4	11.01	39.5	.	3.5	1.7
110.5	5.53	52.6	11.62	33.1	.	3.3	1.6
108.1	5.83	51.4	12.26	33.1	.	3.3	1.6
107.0	6.21	50.9	13.05	33.1	.	3.2	1.5
93.0	8.22	44.2	17.28	28.8	.	3.2	1.5
84.0	8.25	40.0	17.33	26.4	.	3.2	1.5
81.8	8.28	38.9	17.40	26.4	.	3.1	1.5
66.2	8.36	31.5	17.57	22.0	.	3.0	1.4
66.1	8.37	31.4	17.59	22.0	.	3.0	1.4
63.2	8.65	30.1	18.18	21.0	.	3.0	1.4
62.8	8.79	29.9	18.47	21.0	.	3.0	1.4
34.7	9.84	16.5	20.68	11.6	.	3.0	1.4
29.1	12.60	13.9	26.48	9.9	.	2.9	1.4
28.5	12.87	13.6	27.05	9.7	.	2.9	1.4
25.7	13.13	12.2	27.60	8.6	.	3.0	1.4
23.4	13.13	11.1	27.60	8.6	.	2.7	1.3
23.3	14.08	11.1	29.59	8.6	.	2.7	1.3
8.7	14.14	4.1	29.72	2.9	.	3.0	1.4
8.4	14.94	3.4	31.40	2.8	.	3.0	1.4
7.2	18.87	3.4	39.66	2.8	.	2.6	1.2

Table 9Aii. Demand for irrigation water on new land where development is not constrained to develop poor land with good land (Region 1 - Great Salt Lake Desert).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount Thousand Acre-Feet	Price Dollars	Amount Thousand Acre-Feet	Price Dollars	Old Land Thousand Acres	New Land Thousand Acres	Div-erted Acre Feet	Con-sumed Acre Feet
4762.3	.63	2265.9	1.33	.	1274.6	3.7	1.8
4539.3	2.45	2159.8	5.16	.	1197.2	3.8	1.8
4530.8	2.70	2155.8	5.68	.	1195.2	3.8	1.8
4488.4	2.71	2135.6	5.69	.	1195.2	3.8	1.8
4331.9	3.27	2061.1	6.87	.	1156.3	3.7	1.8
3866.7	3.29	1839.8	6.91	.	1055.7	3.7	1.7
3473.3	3.44	1652.6	7.22	.	962.1	3.6	1.7
3373.1	3.96	1604.9	8.32	.	962.1	3.5	1.7
2906.4	3.97	1382.9	8.35	.	839.7	3.5	1.6
2822.6	4.45	1343.0	9.35	.	839.7	3.4	1.6
2748.1	4.76	1307.5	10.00	.	814.8	3.4	1.6
2704.4	4.88	1286.8	10.25	.	814.8	3.3	1.6
2655.3	5.39	1263.4	11.33	.	814.8	3.3	1.6
2646.4	5.53	1259.2	11.61	.	812.7	3.3	1.5
2520.2	5.83	1199.1	12.26	.	768.9	3.3	1.6
2475.3	5.99	1177.7	12.59	.	768.9	3.2	1.5
2407.5	6.05	1145.5	12.71	.	749.4	3.2	1.5
1854.9	6.27	882.6	13.18	.	564.6	3.3	1.6
1488.3	6.47	708.1	13.60	.	466.7	3.2	1.5
1221.2	7.60	581.0	15.98	.	400.6	3.0	1.5
959.8	8.36	456.7	17.57	.	320.6	3.0	1.4
955.1	8.65	454.4	18.18	.	320.6	3.0	1.4
938.5	9.48	446.5	19.93	.	320.6	2.9	1.4
938.2	9.91	446.4	20.83	.	320.5	2.9	1.4
875.7	9.97	416.6	20.96	.	299.6	2.9	1.4
759.1	10.62	361.2	22.32	.	253.4	3.0	1.4
737.9	11.51	351.1	24.18	.	246.5	3.0	1.4
275.6	12.13	131.1	25.49	.	91.9	3.0	1.4
265.8	14.69	126.5	30.87	.	88.9	3.0	1.4
234.1	14.94	111.4	31.40	.	78.3	3.0	1.4
201.4	16.50	95.8	34.68	.	78.3	2.6	1.2

Table 9Aiii. Demand for irrigation water on new land where development is constrained to develop poor land with good land (Region 1 - Great Salt Lake Desert).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
6411.1	1.63	3050.4	3.42	.	1675.8	3.8	1.8
5928.4	2.26	2820.7	4.75	.	1555.8	3.8	1.8
4593.2	2.70	2185.5	5.68	.	1270.9	3.6	1.7
4550.8	3.13	2165.3	6.59	.	1270.9	3.6	1.7
4536.0	3.16	2158.2	6.64	.	1267.4	3.6	1.7
4531.0	3.19	2155.9	6.71	.	1266.2	3.6	1.7
4485.5	3.31	2134.2	6.96	.	1266.2	3.5	1.7
4485.1	3.44	2134.0	7.22	.	1266.1	3.5	1.7
4385.0	3.65	2086.4	7.67	.	1266.1	3.5	1.6
4384.7	3.97	2086.3	8.35	.	1266.0	3.5	1.6
4300.9	4.01	2046.4	8.42	.	1266.0	3.4	1.6
3334.0	4.07	1586.3	8.55	.	1024.4	3.3	1.5
2324.5	4.45	1106.0	9.34	.	759.3	3.1	1.5
1842.0	4.49	876.4	9.44	.	591.9	3.1	1.5
1777.7	5.90	845.8	12.40	.	591.9	3.0	1.4
1721.4	6.20	819.0	13.02	.	591.9	2.9	1.4
1517.4	6.78	722.0	14.25	.	521.7	2.9	1.4
1517.0	7.59	721.8	15.95	.	521.6	2.9	1.4
1516.1	7.84	721.4	16.47	.	521.3	2.9	1.4

Table 9Bi. Demand for irrigation water on presently irrigated land (Region 2 - Bear River).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Diverted	Consumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
945.5	.84	323.6	2.45	246.0	.	3.8	1.3
932.3	.88	319.1	2.57	241.9	.	3.9	1.3
794.8	1.44	272.1	4.21	202.2	.	3.9	1.3
764.8	1.48	261.8	4.31	202.2	.	3.8	1.3
718.5	1.59	245.9	4.64	192.3	.	3.7	1.3
714.9	2.08	244.7	6.07	192.3	.	3.7	1.3
705.9	2.14	241.6	6.26	192.3	.	3.7	1.3
690.5	2.53	236.3	7.39	188.4	.	3.7	1.3
672.5	3.08	230.2	9.00	188.4	.	3.6	1.2
665.1	3.21	227.7	9.37	186.1	.	3.6	1.2
600.5	3.51	205.6	10.26	167.0	.	3.6	1.2
600.0	3.63	205.4	10.59	167.0	.	3.6	1.2
597.9	3.73	204.6	10.88	167.0	.	3.6	1.2
582.4	4.16	199.4	12.14	167.0	.	3.5	1.2
577.6	4.16	197.7	12.15	167.0	.	3.5	1.2
566.5	4.22	193.9	12.33	161.8	.	3.5	1.2
542.1	5.70	185.5	16.67	161.8	.	3.4	1.1
516.2	8.56	176.7	25.00	161.8	.	3.2	1.1
502.4	8.80	172.0	25.70	161.8	.	3.1	1.1
362.0	8.96	123.9	26.17	120.1	.	3.0	1.0
346.5	10.04	118.6	29.33	120.1	.	2.9	1.0
338.7	10.18	115.9	29.73	120.1	.	2.8	1.0
336.6	11.16	115.2	30.63	120.1	.	2.8	1.0
266.3	11.81	91.1	34.50	88.6	.	3.0	1.0
244.3	13.44	83.6	39.25	88.6	.	2.8	.9
243.8	13.80	83.5	40.31	88.6	.	2.8	.9
159.7	17.52	54.7	51.17	63.6	.	2.5	.9
102.3	17.86	35.0	52.18	37.9	.	2.7	.9
60.2	18.01	20.6	52.61	25.4	.	2.4	.8
2.6	22.81	.9	66.65	1.1	.	2.3	.8
2.1	23.62	.7	68.99	.9	.	2.4	.8

Table 9Bii. Demand for irrigation water on new land where development is not constrained to develop poor land with good land (Region 2 - Bear River).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
657.9	.10	225.2	.30	.	168.9	3.9	1.3
632.2	.80	216.4	2.32	.	161.3	3.9	1.3
630.8	1.44	215.9	4.20	.	160.9	3.9	1.3
596.8	1.44	204.3	4.21	.	151.1	3.9	1.4
573.4	2.08	196.3	6.07	.	151.1	3.8	1.3
563.4	2.53	192.9	7.39	.	151.1	3.7	1.3
543.8	3.51	186.1	10.26	.	151.1	3.6	1.2
543.3	3.73	186.0	10.88	.	151.1	3.6	1.2
530.7	4.22	181.7	12.33	.	151.1	3.5	1.2
505.9	4.81	173.2	14.06	.	151.1	3.3	1.1
490.3	5.53	167.8	16.16	.	147.2	3.3	1.1
455.3	5.70	155.8	16.67	.	134.2	3.4	1.2
437.5	5.71	149.8	16.69	.	134.2	3.3	1.1
423.6	6.06	145.0	17.72	.	129.2	3.3	1.1
326.9	7.42	111.9	21.69	.	100.5	3.3	1.1
305.8	8.96	104.7	26.17	.	92.9	3.3	1.1
288.8	9.92	98.9	28.97	.	92.9	3.1	1.1
277.7	10.04	95.1	29.33	.	89.6	3.1	1.1
269.2	11.33	92.1	33.11	.	89.6	3.0	1.0
188.4	11.68	64.5	34.13	.	65.6	2.9	1.0
117.2	11.81	40.1	34.50	.	39.2	3.0	1.0
107.2	12.50	36.7	36.52	.	39.2	2.7	.9
85.1	13.44	29.1	39.25	.	29.9	2.8	1.0
84.6	14.34	29.0	41.88	.	29.9	2.8	1.0
79.2	14.51	27.1	42.39	.	28.3	2.8	1.0
43.7	15.75	14.9	46.02	.	13.3	3.3	1.1
2.6	17.49	.9	51.11	.	1.1	2.3	.8
2.1	18.61	.7	54.38	.	.9	2.4	.8
.7	20.62	.2	60.25	.	.3	2.4	.8

Table 9Biii. Demand for irrigation water on new land where development is constrained to develop poor land with good land (Region 2 - Bear River).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
772.0	1.44	264.3	4.21	.	194.8	4.0	1.4
748.6	1.59	256.2	4.64	.	194.8	3.8	1.3
731.6	2.08	250.4	6.07	.	194.8	3.8	1.3
721.7	2.53	247.0	7.39	.	194.8	3.7	1.3
702.0	3.41	240.3	9.95	.	194.8	3.6	1.2
686.9	3.51	235.1	10.26	.	194.8	3.5	1.2
686.4	3.54	235.0	10.33	.	194.8	3.5	1.2
671.8	3.73	230.0	10.88	.	194.8	3.4	1.2
659.3	4.22	225.7	12.33	.	194.8	3.4	1.2
634.5	5.31	217.2	15.50	.	194.8	3.3	1.1
620.9	5.70	212.5	16.67	.	194.8	3.2	1.1
600.7	6.48	205.6	18.94	.	194.8	3.1	1.1
562.4	6.68	192.5	19.52	.	184.1	3.1	1.0
561.1	6.72	192.1	19.64	.	183.8	3.1	1.0
512.7	6.74	175.5	19.69	.	165.1	3.1	1.1
462.2	6.78	145.9	19.80	.	131.7	3.2	1.1
422.8	7.15	144.7	20.89	.	130.4	3.2	1.1
422.7	7.23	144.7	21.11	.	130.3	3.2	1.1
372.8	7.42	127.6	21.66	.	111.5	3.3	1.1
372.6	7.81	127.5	22.81	.	111.5	3.3	1.1
81.1	8.12	27.8	23.72	.	30.6	2.7	.9
80.9	8.56	27.7	25.00	.	30.5	2.7	.9
77.8	9.02	26.6	26.36	.	30.5	2.6	.9
71.5	9.04	24.5	26.42	.	28.0	2.6	.9

Table 9Ci. Demand for irrigation water on presently irrigated land (Region 3 - Weber River).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
612.4	1.54	224.6	4.19	150.7	.	4.1	1.5
608.1	1.54	223.0	4.19	150.7	.	4.0	1.5
597.2	1.57	219.0	4.29	150.7	.	4.0	1.5
593.1	1.73	217.5	4.72	150.7	.	3.9	1.4
589.7	1.96	216.3	5.33	150.7	.	3.9	1.4
582.8	2.15	213.7	5.87	150.7	.	3.9	1.4
570.8	2.17	209.3	5.93	150.7	.	3.8	1.4
556.5	2.18	204.1	5.95	146.8	.	3.8	1.4
549.7	2.25	201.6	6.13	144.8	.	3.8	1.4
534.1	2.58	195.9	7.05	140.4	.	3.8	1.4
520.5	2.84	190.9	7.75	140.4	.	3.7	1.4
514.7	2.84	188.7	7.75	140.4	.	3.7	1.3
506.6	3.03	185.8	8.27	140.4	.	3.6	1.3
497.7	3.34	182.5	9.10	140.4	.	3.5	1.3
474.6	3.85	174.0	10.33	140.4	.	3.4	1.2
466.5	4.24	171.1	11.56	140.4	.	3.3	1.2
449.6	5.51	164.9	15.04	133.5	.	3.4	1.2
445.6	6.19	163.4	16.88	133.5	.	3.3	1.2
445.2	7.27	163.2	19.83	133.5	.	3.3	1.2
439.6	7.27	161.2	19.83	133.5	.	3.3	1.2
429.1	8.25	157.4	22.50	133.5	.	3.2	1.2
390.0	9.08	143.0	24.77	133.5	.	2.9	1.1
363.9	9.43	133.4	25.73	124.6	.	2.9	1.1
355.7	9.46	130.4	25.81	121.7	.	2.9	1.1
353.2	9.60	129.5	26.17	120.8	.	2.9	1.1
346.1	9.60	126.9	26.17	120.8	.	2.9	1.1
325.8	9.65	119.5	26.31	120.8	.	2.7	1.0
300.8	9.96	110.3	27.15	112.7	.	2.7	1.0
281.9	10.15	103.4	29.33	106.4	.	2.6	1.0
271.1	10.76	99.4	29.33	106.4	.	2.5	.9
264.1	14.03	96.8	38.26	106.4	.	2.5	.9
243.2	14.43	89.2	39.34	99.1	.	2.5	.9
189.5	15.01	69.5	40.94	80.8	.	2.3	.9
181.3	15.65	66.5	42.67	77.9	.	2.3	.9
136.8	15.91	50.2	43.39	63.5	.	2.2	.8
114.3	16.17	41.9	44.11	38.4	.	3.0	1.1
87.3	18.63	32.0	50.80	29.4	.	3.0	1.1
69.7	19.34	25.6	52.75	23.4	.	3.0	1.1
54.5	20.23	20.0	55.16	18.0	.	3.0	1.1
37.8	20.88	13.8	56.94	12.6	.	3.0	1.1

Table 9Cii. Demand for irrigation water on new land where development is not constrained to develop poor land with good land (Region 3 - Weber River).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
118.2	1.96	43.3	5.33	.	27.5	4.3	1.6
112.4	2.15	41.2	5.87	.	27.5	4.1	1.5
104.7	2.58	38.4	7.05	.	27.5	3.8	1.4
104.5	2.84	38.3	7.75	.	27.5	3.8	1.4
104.2	3.03	38.2	8.27	.	27.5	3.8	1.4
100.6	3.34	36.9	9.10	.	27.5	3.7	1.3
98.3	4.58	36.1	12.49	.	27.5	3.6	1.3
91.9	4.72	33.7	12.88	.	25.7	3.6	1.3
89.4	5.91	32.8	16.12	.	25.0	3.6	1.3
73.0	6.10	26.8	16.62	.	20.4	3.6	1.3
67.7	6.50	24.8	17.71	.	18.9	3.6	1.3
51.2	6.67	18.8	18.19	.	14.4	3.6	1.3
31.9	6.89	11.7	18.79	.	9.0	3.5	1.3
31.2	9.60	11.4	26.17	.	8.7	3.6	1.3
28.4	9.60	10.4	26.17	.	8.7	3.3	1.2
26.4	9.63	9.7	26.27	.	8.7	3.0	1.1
24.9	10.03	9.1	27.36	.	8.2	3.0	1.1
23.8	10.76	8.7	29.33	.	7.8	3.0	1.1
23.6	10.76	8.7	29.33	.	7.8	3.0	1.1
23.3	11.26	8.5	30.70	.	7.8	3.0	1.1
20.4	11.72	7.5	31.96	.	6.8	3.0	1.1
18.4	12.64	6.7	34.47	.	6.1	3.0	1.1
12.8	13.07	4.7	35.65	.	4.3	3.0	1.1
2.0	14.24	.7	38.84	.	.7	2.9	1.1
1.7	15.87	.6	43.27	.	.6	2.9	1.1
.6	16.48	.2	44.93	.	.2	2.8	1.0

Table 9Ciii. Demand for irrigation water on new land where development is constrained to develop poor land with good land (Region 3 - Weber River).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Diverted	Consumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
217.8	1.57	79.9	4.19	.	49.9	4.4	1.6
210.8	1.73	77.3	4.72	.	49.9	4.2	1.5
198.7	1.94	72.9	5.29	.	49.9	4.0	1.5
181.1	1.96	66.4	5.33	.	45.5	4.0	1.5
175.4	2.00	64.3	5.45	.	45.5	3.9	1.4
173.2	2.08	63.5	5.66	.	44.6	3.9	1.4
172.1	2.15	63.1	5.87	.	44.3	3.9	1.4
165.6	2.58	60.7	7.05	.	44.3	3.7	1.4
165.5	2.70	60.7	7.37	.	44.3	3.7	1.4
165.0	2.84	60.5	7.75	.	44.2	3.7	1.4
164.7	3.03	60.4	8.27	.	44.2	3.7	1.4
161.2	3.18	59.1	8.68	.	44.2	3.6	1.3
157.6	3.21	57.8	8.75	.	43.3	3.6	1.3
130.0	3.34	47.7	9.10	.	35.8	3.6	1.3
128.8	3.36	47.2	9.17	.	35.8	3.6	1.3
114.9	3.37	42.1	9.18	.	32.0	3.6	1.3
109.3	3.61	40.1	9.83	.	30.4	3.6	1.3
65.3	3.79	24.0	10.33	.	18.4	3.6	1.3
60.2	3.89	22.1	10.60	.	18.4	3.3	1.2
59.9	4.23	22.0	11.55	.	18.3	3.3	1.2
59.4	4.80	21.8	13.08	.	18.2	3.3	1.2
50.3	5.15	18.4	14.04	.	15.3	3.3	1.2
46.7	5.40	17.1	14.72	.	14.2	3.3	1.2

Table 9Di. Demand for irrigation water on presently irrigated land (Region 4 - Jordan River).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Diverted	Consumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
976.6	.90	380.0	2.31	212.5	.	4.6	1.8
966.0	1.04	375.9	2.67	212.5	.	4.5	1.8
963.4	1.05	374.8	2.70	212.5	.	4.5	1.8
956.2	1.27	372.0	3.26	212.5	.	4.5	1.8
940.7	1.28	366.0	3.28	212.5	.	4.4	1.7
937.0	1.58	364.6	4.06	211.3	.	4.4	1.7
919.6	1.58	357.8	4.06	211.3	.	4.4	1.7
902.1	1.73	351.0	4.44	211.3	.	4.3	1.7
858.1	1.88	333.9	4.83	200.3	.	4.3	1.7
737.4	2.32	286.9	5.96	174.0	.	4.2	1.6
730.4	2.39	284.2	6.15	174.0	.	4.2	1.6
724.7	2.72	282.0	6.98	174.0	.	4.2	1.6
719.0	2.83	279.8	7.27	174.0	.	4.1	1.6
690.4	3.20	268.6	8.21	174.0	.	4.0	1.5
685.7	3.50	266.8	9.00	174.0	.	3.9	1.5
678.1	3.62	263.8	9.30	174.0	.	3.9	1.5
670.9	3.63	261.0	9.33	174.0	.	3.9	1.5
664.7	4.12	258.6	10.58	174.0	.	3.8	1.5
655.8	4.20	255.2	10.80	174.0	.	3.8	1.5
629.1	5.30	244.8	13.62	174.0	.	3.6	1.4
605.8	5.57	235.7	14.31	164.8	.	3.7	1.4
589.8	6.74	229.5	17.33	159.4	.	3.7	1.4
578.5	7.72	225.1	19.83	159.4	.	3.6	1.4
551.2	7.83	214.5	20.11	159.4	.	3.5	1.3
540.5	8.02	210.3	20.61	156.2	.	3.5	1.3
447.4	8.30	174.1	21.34	126.9	.	3.5	1.4
387.5	8.49	150.8	21.81	109.8	.	3.5	1.4
330.9	9.21	128.8	23.67	92.7	.	3.6	1.4
325.8	9.27	126.7	23.83	92.7	.	3.5	1.4
306.8	10.18	119.4	26.17	86.3	.	3.6	1.4
281.3	10.44	109.5	26.83	86.3	.	3.3	1.3
277.1	11.06	107.8	28.43	86.3	.	3.2	1.2
256.2	11.41	99.7	29.33	86.3	.	3.0	1.2
250.3	12.53	97.4	32.20	86.3	.	2.9	1.1
243.6	12.95	94.8	33.29	84.3	.	2.9	1.1
157.5	13.54	61.3	34.79	57.2	.	2.8	1.1
137.2	13.60	53.4	34.95	40.9	.	3.4	1.3
111.9	13.76	43.6	35.35	33.7	.	3.3	1.3
58.3	16.46	22.7	42.29	17.5	.	3.3	1.3
54.3	16.83	21.1	43.26	16.3	.	3.3	1.3
34.0	17.84	13.2	45.84	9.9	.	3.4	1.3
11.9	17.91	4.6	46.03	3.6	.	3.3	1.3

Table 9Dii. Demand for irrigation water on new land where development is not constrained to develop poor land with good land (Region 4 - Jordan River).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
1007.9	.37	392.2	.94	.	223.3	4.5	1.8
992.9	1.27	386.4	3.26	.	217.4	4.6	1.8
970.4	1.82	377.6	4.67	.	217.4	4.5	1.7
968.3	2.32	376.8	5.96	.	217.0	4.5	1.7
950.0	2.39	369.7	6.15	.	217.0	4.4	1.7
940.0	2.48	365.8	6.38	.	217.0	4.3	1.7
871.3	2.72	339.0	6.98	.	203.9	4.3	1.7
858.5	2.83	334.0	7.27	.	203.9	4.2	1.6
828.7	3.61	322.4	9.28	.	203.9	4.1	1.6
808.2	3.63	314.5	9.33	.	198.7	4.1	1.6
801.2	3.76	311.7	9.66	.	198.7	4.0	1.6
783.7	4.12	304.9	10.58	.	194.1	4.0	1.6
763.4	4.15	297.0	10.67	.	194.1	3.9	1.5
758.5	4.20	295.1	10.80	.	192.9	3.9	1.5
725.2	4.62	282.2	11.88	.	192.9	3.8	1.5
723.7	5.02	281.6	12.89	.	192.4	3.8	1.5
622.9	5.33	242.4	13.69	.	165.8	3.8	1.5
529.3	5.47	206.0	14.07	.	142.7	3.7	1.4
463.4	5.80	180.3	14.91	.	125.6	3.7	1.4
421.9	7.86	164.1	20.20	.	111.6	3.8	1.5
398.5	8.19	155.1	21.06	.	102.4	3.9	1.5
379.2	8.53	147.6	21.92	.	97.5	3.9	1.5
359.9	9.21	140.0	23.67	.	92.4	3.9	1.5
349.6	9.30	136.0	23.90	.	92.4	3.8	1.5
348.9	9.79	135.7	25.15	.	92.2	3.8	1.5
238.2	10.18	92.7	26.17	.	63.0	3.8	1.5
227.4	10.44	88.5	26.83	.	63.0	3.6	1.4
220.1	10.64	85.6	27.36	.	63.0	3.5	1.4
154.6	10.66	60.1	27.40	.	43.2	3.6	1.4
89.0	11.41	34.6	29.33	.	24.5	3.6	1.4
82.3	12.29	32.0	31.60	.	24.5	3.4	1.3
74.7	12.47	29.1	32.04	.	22.2	3.4	1.3
71.2	13.88	27.7	35.67	.	21.1	3.4	1.3
69.4	13.97	27.0	35.90	.	20.6	3.4	1.3
51.0	15.16	19.8	38.97	.	14.8	3.4	1.3
36.1	15.24	14.0	39.16	.	10.3	3.5	1.4

Table 9Diii. Demand for irrigation water on new land where development is constrained to develop poor land with good land (Region 4 - Jordan River).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Diverted	Consumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
1367.2	.64	532.0	1.66	.	296.4	4.6	1.8
1358.8	.81	528.7	2.08	.	294.8	4.6	1.8
1358.6	.90	528.6	2.31	.	294.7	4.6	1.8
1341.7	1.04	522.1	2.67	.	294.7	4.6	1.8
1284.9	1.16	499.9	2.98	.	294.7	4.4	1.7
1283.9	1.27	499.5	3.26	.	294.5	4.4	1.7
1261.3	1.38	490.8	3.55	.	294.5	4.3	1.7
1041.1	2.32	405.1	5.96	.	241.8	4.3	1.7
1022.9	2.34	398.0	6.02	.	241.8	4.2	1.6
1001.6	2.39	389.7	6.15	.	241.8	4.1	1.6
991.6	2.83	385.8	7.27	.	241.8	4.1	1.6
961.8	3.05	374.2	7.83	.	241.8	4.0	1.5
949.4	3.63	369.4	9.33	.	241.8	3.9	1.5
942.4	4.02	366.7	10.33	.	241.8	3.9	1.5
922.1	4.20	358.8	10.80	.	241.8	3.8	1.5
888.8	4.93	345.8	12.68	.	241.8	3.7	1.4
850.6	4.94	331.0	12.70	.	226.7	3.8	1.5
803.1	4.97	312.5	12.77	.	213.7	3.8	1.5
747.0	5.21	290.6	13.38	.	199.0	3.8	1.5
746.2	5.23	290.4	13.45	.	198.8	3.8	1.5
746.1	5.42	290.3	13.92	.	198.7	3.8	1.5
736.5	5.70	286.6	14.64	.	196.2	3.8	1.5
735.4	5.76	286.2	14.80	.	195.9	3.8	1.5
732.8	5.80	285.1	14.91	.	195.3	3.8	1.5
732.3	5.95	284.9	15.29	.	195.1	3.8	1.5
732.2	6.24	284.9	16.04	.	195.1	3.8	1.5
466.2	6.30	181.4	16.19	.	122.5	3.8	1.5
465.7	6.34	181.2	16.30	.	122.3	3.8	1.5
450.6	6.56	175.3	16.85	.	118.2	3.8	1.5
450.2	6.68	175.2	17.16	.	118.1	3.8	1.5
443.5	6.74	172.6	17.33	.	116.3	3.8	1.5
430.9	6.83	167.7	17.55	.	116.3	3.7	1.4
243.4	7.00	94.7	17.99	.	65.8	3.7	1.4

Table 9Ei. Demand for irrigation water on presently irrigated land (Region 5 - Sevier River).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
1670.4	1.09	542.9	3.37	285.5	.	5.9	1.9
1663.3	1.22	540.6	3.74	285.5	.	5.8	1.9
1655.1	1.28	537.9	3.94	284.2	.	5.8	1.9
1650.9	1.28	536.6	3.94	284.2	.	5.8	1.9
1646.2	1.31	535.0	4.02	284.2	.	5.8	1.9
1638.0	1.51	532.3	4.65	282.8	.	5.8	1.9
1588.3	1.66	516.2	5.12	282.8	.	5.6	1.8
1578.3	1.77	512.9	5.46	280.9	.	5.6	1.8
1574.4	1.81	511.7	5.56	280.2	.	5.6	1.8
1538.4	1.81	500.0	5.58	273.7	.	5.6	1.8
1538.1	2.73	499.9	8.39	273.7	.	5.6	1.8
1534.7	2.86	498.8	8.79	273.7	.	5.6	1.8
1530.9	3.13	497.5	9.62	273.7	.	5.6	1.8
1518.5	3.19	493.5	9.81	273.7	.	5.5	1.8
1421.5	3.20	462.0	9.84	273.7	.	5.2	1.7
1406.1	3.22	457.0	9.92	273.7	.	5.1	1.7
1378.5	3.26	448.0	10.04	273.7	.	5.0	1.6
1373.5	4.12	446.4	12.69	272.2	.	5.0	1.6
1357.8	4.54	441.3	13.98	268.7	.	5.1	1.6
1297.3	4.55	421.6	13.99	256.8	.	5.1	1.6
1238.3	5.25	402.4	16.16	245.6	.	5.0	1.6
1095.0	5.53	355.9	17.00	218.8	.	5.0	1.6
1081.5	5.55	351.5	17.08	218.8	.	4.9	1.6
985.1	6.52	320.2	20.06	196.8	.	5.0	1.6
967.7	6.72	314.5	20.68	192.9	.	5.0	1.6
939.4	6.92	305.3	21.28	192.9	.	4.9	1.6
907.3	7.32	294.9	22.52	186.8	.	4.9	1.6
430.7	7.45	140.0	22.91	93.0	.	4.6	1.5
395.2	8.00	128.4	24.60	82.5	.	4.8	1.6
371.1	8.07	120.6	24.84	82.5	.	4.5	1.5
179.0	8.80	58.2	27.09	41.3	.	4.3	1.4
6.4	10.34	2.1	31.81	1.9	.	3.4	1.1

Table 9Eii. Demand for irrigation water on new land where development is not constrained to develop poor land with good land (Region 5 - Sevier River).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
3116.0	.16	1012.7	.49	.	543.7	5.7	1.9
3069.6	.86	997.6	2.64	.	530.0	5.8	1.9
3063.5	1.37	995.6	4.22	.	529.1	5.8	1.9
2862.5	1.54	930.3	4.75	.	499.6	5.7	1.9
2856.0	2.19	928.2	6.73	.	498.4	5.7	1.9
2660.3	2.58	864.6	7.94	.	462.5	5.8	1.9
2653.5	2.64	862.4	8.13	.	461.5	5.7	1.9
2629.0	2.80	854.4	8.62	.	457.5	5.7	1.9
1478.7	2.80	480.6	8.62	.	269.4	5.5	1.8
1468.2	2.86	477.2	8.79	.	267.4	5.5	1.8
1430.0	2.88	464.7	8.85	.	267.4	5.3	1.7
1427.8	3.09	464.0	9.52	.	267.0	5.3	1.7
1215.9	3.19	395.2	9.81	.	235.9	5.2	1.7
1090.4	3.20	354.4	9.84	.	235.9	4.6	1.5
1088.4	3.22	353.7	9.92	.	235.9	4.6	1.5
1085.6	3.53	352.8	10.87	.	235.9	4.6	1.5
1065.3	3.70	346.2	11.40	.	232.1	4.6	1.5
1051.3	3.88	341.7	11.94	.	229.3	4.6	1.5
1046.0	4.66	339.9	14.35	.	228.1	4.6	1.5
875.9	4.73	284.7	14.55	.	190.1	4.6	1.5
742.2	5.34	241.2	16.44	.	150.6	4.9	1.6
724.3	5.50	235.4	16.91	.	147.2	4.9	1.6
711.6	5.68	231.3	17.49	.	144.7	4.9	1.6
108.0	5.69	35.1	17.52	.	25.9	4.2	1.4
104.3	6.35	33.9	19.53	.	25.2	4.1	1.3
70.1	7.04	22.8	21.67	.	18.8	3.7	1.2
50.1	.7.88	16.3	24.26	.	14.8	3.4	1.1

Table 9Eiii. Demand for irrigation water on new land where development is constrained to develop poor land with good land (Region 5 - Sevier River).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Diverted	Consumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
3630.9	1.77	1180.0	5.44	.	615.9	5.9	1.9
3561.2	1.81	1157.4	5.58	.	604.7	5.9	1.9
3289.5	1.82	1069.1	5.61	.	604.7	5.4	1.8
3289.1	1.86	1068.9	5.72	.	604.6	5.4	1.8
3288.9	1.93	1068.9	5.94	.	604.5	5.4	1.8
230.1	4.49	74.8	13.83	.	68.0	3.4	1.1

Table 9Fi. Demand for irrigation water on presently irrigated land (Region 6 - Cedar-Beaver).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Diverted	Consumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
299.2	1.25	136.2	2.74	79.3	.	3.8	1.7
298.7	2.06	136.0	4.53	79.3	.	3.8	1.7
294.5	2.12	134.1	4.65	78.3	.	3.8	1.7
293.0	2.21	133.4	4.86	78.3	.	3.7	1.7
271.1	2.58	123.4	5.66	72.7	.	3.7	1.7
267.2	2.67	121.7	5.86	71.5	.	3.7	1.7
266.6	4.78	121.4	10.49	71.5	.	3.7	1.7
266.5	5.41	121.3	11.89	71.5	.	3.7	1.7
261.9	5.75	119.2	12.63	71.5	.	3.7	1.7
236.2	6.17	107.6	13.56	65.4	.	3.6	1.6
231.6	6.32	105.5	13.87	65.4	.	3.5	1.6
214.4	7.73	97.6	16.97	65.4	.	3.3	1.5
187.5	8.36	85.4	18.36	57.1	.	3.3	1.5
163.5	8.79	74.4	19.31	49.6	.	3.3	1.5
159.1	9.21	72.5	20.23	49.6	.	3.2	1.5
129.7	12.36	59.1	27.15	41.5	.	3.1	1.4
28.0	12.41	12.7	27.25	10.1	.	2.8	1.3
20.1	13.15	9.2	28.89	10.1	.	2.0	.9
1.0	14.30	.4	31.40	.3	.	3.2	1.5
.8	16.21	.4	35.60	.3	.	2.8	1.3

Table 9Fii. Demand for irrigation water on new land where development is not constrained to develop poor land with good land (Region 6 - Cedar-Beaver).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Diverted	Consumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
1928.4	2.73	878.0	6.00	.	494.3	3.9	1.8
1844.5	3.33	839.8	7.31	.	494.3	3.7	1.7
1524.5	3.75	694.1	8.23	.	418.2	3.6	1.7
1349.5	4.70	614.4	10.32	.	377.6	3.6	1.6
881.2	4.78	401.2	10.49	.	254.0	3.5	1.6
881.1	5.17	401.2	11.36	.	254.0	3.5	1.6
792.1	6.17	360.7	13.56	.	226.2	3.5	1.6
777.0	6.32	353.8	13.87	.	226.2	3.4	1.6
687.4	6.65	313.0	14.60	.	226.2	3.0	1.4
590.7	8.79	269.0	19.31	.	199.6	3.0	1.3
586.4	9.49	267.0	20.84	.	199.6	2.9	1.3
58.0	9.56	26.4	21.00	.	36.5	1.6	.7
31.3	13.45	14.3	29.54	.	26.8	1.2	.5
30.7	14.74	14.0	32.37	.	26.6	1.2	.5
22.5	22.73	10.3	49.93	.	26.6	.8	.4

Table 9Fiii. Demand for irrigation water on new land where development is constrained to develop poor land with good land (Region 6 - Cedar-Beaver).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Diverted	Consumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
3295.8	1.47	1500.6	3.23	.	835.8	3.9	1.8
2319.9	2.21	1056.3	4.85	.	603.7	3.8	1.7
2048.6	2.34	932.7	5.14	.	518.9	3.9	1.8
2009.3	2.65	914.8	5.82	.	518.9	3.9	1.8
1546.0	3.81	703.9	8.36	.	403.9	3.8	1.7
1472.5	4.78	670.4	10.49	.	403.9	3.6	1.7
1472.4	4.87	670.4	10.70	.	403.9	3.6	1.7

Table 9Gi. Demand for irrigation water on presently irrigated land (Region 7 - Uintah Basin).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
1104.8	.24	410.1	.64	217.8	.	5.1	1.9
1088.5	.29	404.0	.79	213.9	.	5.1	1.9
1082.0	.82	401.7	2.21	212.2	.	5.1	1.9
999.1	1.18	370.9	3.17	196.0	.	5.1	1.9
947.2	1.73	351.6	4.65	185.3	.	5.1	1.9
780.9	1.96	289.9	5.29	154.2	.	5.1	1.9
703.6	2.47	261.2	6.67	139.1	.	5.1	1.9
703.6	3.20	261.1	8.63	139.1	.	5.1	1.9
687.4	3.68	255.2	9.92	139.1	.	4.9	1.8
670.7	4.13	249.0	11.12	135.1	.	5.0	1.8
424.9	4.22	157.7	11.36	87.7	.	4.8	1.8
405.9	5.11	150.7	13.76	87.7	.	4.6	1.7
268.4	5.59	99.6	15.06	56.1	.	4.8	1.8
251.3	6.82	93.3	18.36	56.1	.	4.5	1.7
117.0	7.54	43.4	20.30	26.9	.	4.4	1.6
88.2	8.40	32.7	22.64	26.9	.	3.3	1.2

Table 9Gii. Demand for irrigation water on new land where development is not constrained to develop poor land with good land (Region 7 - Uintah Basin).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
1349.8	.11	501.1	.29	.	268.2	5.0	1.9
1168.1	1.73	433.6	4.65	.	232.7	5.0	1.9
1141.3	2.54	423.6	6.86	.	226.3	5.0	1.9
866.4	3.20	321.6	8.63	.	173.3	5.0	1.9
828.7	3.34	307.6	9.00	.	173.3	4.8	1.8
462.4	5.27	171.6	14.19	.	99.3	4.7	1.7
273.6	6.51	101.6	17.54	.	62.9	4.4	1.6

Table 9Giii. Demand for irrigation water on new land where development is constrained to develop poor land with good land (Region 7 - Uintah Basin).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
1561.3	2.40	579.6	6.46	.	306.3	5.1	1.9
859.3	3.20	319.0	8.63	.	172.4	5.0	1.9
821.5	3.68	304.9	9.92	.	172.4	4.8	1.8

Table 9Hi. Demand for irrigation water on presently irrigated land (Region 8 - West Colorado).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
434.6	1.20	163.0	3.20	80.5	.	5.4	.
423.4	1.28	158.8	3.41	80.5	.	5.3	.
415.7	1.65	155.9	4.40	79.1	.	5.3	.
385.0	1.74	144.4	4.65	72.8	.	5.3	.
330.6	2.12	124.4	5.65	72.8	.	4.5	.
328.9	2.27	123.3	6.07	72.4	.	4.5	
326.8	2.37	122.6	6.31	71.8	.	4.6	.
325.8	2.66	122.2	7.10	71.8	.	4.5	.
325.7	3.19	122.1	8.50	71.8	.	4.5	.
303.4	3.62	113.8	9.66	71.8	.	4.2	.
303.2	3.90	113.7	10.40	71.8	.	4.2	.
269.7	4.13	101.1	11.00	71.8	.	3.8	.
263.0	4.36	98.6	11.64	71.8	.	3.7	.
261.9	4.55	98.2	12.14	71.6	.	3.7	.
239.9	4.80	90.0	12.79	71.6	.	3.4	.
234.3	5.11	87.8	13.61	71.6	.	3.3	.
234.0	5.32	87.7	14.20	71.6	.	3.3	.
233.5	5.45	87.5	14.54	71.6	.	3.3	.
192.1	5.52	72.0	14.72	62.6	.	3.1	.
179.9	5.57	67.5	14.86	59.6	.	3.0	.
179.5	6.58	67.3	17.56	59.6	.	3.0	.
179.1	6.59	67.2	17.57	59.6	.	3.0	.
179.0	6.59	67.1	17.57	59.6	.	3.0	.
178.5	7.16	66.9	19.09	59.6	.	3.0	.
178.0	7.55	66.8	20.13	59.5	.	3.0	.
137.4	7.61	51.5	20.29	46.1	.	3.0	.
137.3	8.16	51.5	21.75	46.1	.	3.0	.
135.2	8.63	50.7	23.00	45.5	.	3.0	.
130.4	8.72	48.9	23.24	45.5	.	2.9	.
100.3	8.92	37.6	23.79	37.9	.	2.6	.
64.5	10.00	24.2	26.66	21.4	.	3.0	.
64.0	10.96	24.0	29.22	21.3	.	3.0	.
3.0	12.94	1.1	34.51	1.2	.	2.5	.
2.4	14.51	.9	38.69	.9	.	2.7	.
.9	17.59	.3	46.89	.4	.	2.2	.

Table 9Hii. Demand for irrigation water on new land where development is not constrained to develop poor land with good land (Region 8 - West Colorado).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
1509.7	1.76	566.1	4.70	.	304.3	5.0	.
1476.5	2.37	553.7	6.33	.	304.3	4.9	.
1462.6	2.52	548.5	6.71	.	304.3	4.8	.
1450.5	2.52	544.0	6.71	.	304.3	4.8	.
1437.4	2.66	539.0	7.10	.	304.3	4.7	.
1433.1	2.67	537.4	7.12	.	304.3	4.7	.
1419.7	3.19	532.4	8.50	.	304.3	4.7	.
1360.9	3.21	510.3	8.56	.	304.3	4.5	.
1208.9	3.58	453.3	9.54	.	267.0	4.5	.
812.4	3.68	304.7	9.80	.	199.0	4.1	.
510.3	3.90	191.4	10.40	.	140.4	3.6	.
432.1	4.55	162.0	12.14	.	140.4	3.1	.
409.6	5.02	153.6	13.39	.	140.4	2.9	.
305.7	5.11	114.6	13.61	.	100.6	3.0	.
305.1	5.32	114.4	14.20	.	100.6	3.0	.
304.1	5.56	114.0	14.81	.	100.6	3.0	.

Table 9Hiii. Demand for irrigation water on new land where development is constrained to develop poor land with good land (Region 8 - West Colorado).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
1177.2	2.66	441.4	7.10	.	238.6	4.9	.
1172.9	2.95	439.8	7.86	.	238.6	4.9	.
1028.3	3.19	385.6	8.50	.	215.4	4.8	.
969.4	3.51	363.5	9.36	.	215.4	4.5	.
883.8	3.73	331.4	9.95	.	194.4	4.5	.
764.4	3.90	286.6	10.40	.	172.0	4.4	.
686.2	4.20	257.3	11.20	.	172.0	4.0	.
664.2	4.55	249.1	12.14	.	172.0	3.9	.
641.6	4.80	240.6	12.79	.	172.0	3.7	.
626.6	4.85	235.0	12.92	.	172.0	3.6	.
519.5	5.11	194.8	13.61	.	136.7	3.8	.
519.0	5.14	194.6	13.72	.	136.7	3.8	.
482.3	5.32	180.8	14.20	.	119.8	4.0	.
481.2	5.57	180.4	14.86	.	119.8	4.0	.
465.1	5.72	174.4	15.26	.	119.8	3.9	.
327.5	6.13	122.8	16.35	.	94.2	3.5	.
295.7	6.59	110.9	17.57	.	86.4	3.4	.
294.4	6.94	110.4	18.50	.	86.4	3.4	.
294.3	7.11	110.4	18.97	.	86.4	3.4	.
200.6	7.61	75.2	20.29	.	66.0	3.0	.
196.9	8.55	73.8	22.80	.	66.0	3.0	.
54.6	8.68	20.5	23.15	.	19.1	2.9	.
31.5	9.58	11.8	25.54	.	14.1	2.2	.
5.2	12.50	2.0	33.33	.	2.0	2.6	.
2.2	14.78	.8	39.40	.	1.0	2.2	.

Table 9Ii. Demand for irrigation water on presently irrigated land (Region 9 - South and East Colorado).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
207.7	.42	41.5	2.12	18.5	.	11.2	2.2
206.5	.49	41.3	2.45	18.5	.	11.2	2.2
200.3	.54	40.1	2.70	18.0	.	11.1	2.2
196.3	.55	39.3	2.74	18.0	.	10.9	2.2
191.6	.86	38.3	4.32	17.6	.	10.9	2.2
187.7	1.06	37.5	5.29	17.6	.	10.7	2.1
171.7	1.19	34.3	5.95	15.8	.	10.9	2.2
170.0	1.31	34.0	6.55	15.8	.	10.8	2.2
167.8	1.36	33.6	6.80	15.8	.	10.6	2.1
165.4	1.66	33.1	8.31	15.8	.	10.5	2.1
161.2	1.73	32.2	8.65	15.8	.	10.2	2.0
123.7	1.95	24.7	9.73	12.6	.	9.8	2.0
121.1	2.09	24.2	10.44	12.6	.	9.6	1.9
99.1	2.29	19.8	11.46	10.5	.	9.4	1.9
97.7	2.61	19.5	13.06	10.5	.	9.3	1.9
89.7	2.78	17.9	13.88	9.7	.	9.2	1.8
24.1	3.38	4.8	16.91	2.3	.	10.5	2.1
10.5	4.49	2.1	22.43	1.0	.	10.5	2.1
8.9	4.77	1.8	23.87	1.0	.	8.9	1.8

Table 9Iii. Demand for irrigation water on new land where development is not constrained to develop poor land with good land (Region 9 - South and East Colorado).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
5167.6	.81	1033.5	4.06	.	533.3	9.7	1.9
4861.9	.86	972.4	4.32	.	507.3	9.6	1.9
4816.2	1.05	963.2	5.24	.	507.3	9.5	1.9
4786.2	1.19	957.2	5.95	.	507.3	9.4	1.9
4776.7	1.31	955.3	6.55	.	507.3	9.4	1.9
4765.3	1.35	953.1	6.75	.	507.3	9.4	1.9
4611.9	1.36	922.4	6.80	.	489.9	9.4	1.9
4560.9	1.46	912.2	7.29	.	489.9	9.3	1.9
4558.3	1.66	911.7	8.31	.	489.6	9.3	1.9
4509.5	1.68	901.9	8.40	.	489.6	9.2	1.8
3699.1	1.73	739.8	8.66	.	417.6	8.9	1.8
3698.6	1.82	739.7	9.11	.	417.6	8.9	1.8

Table 9Iiii. Demand for irrigation water on new land where development is constrained to develop poor land with good land (Region 9 - South and East Colorado).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
1338.6	1.94	267.7	9.36	.	137.4	9.7	1.9
1282.4	1.95	256.5	9.73	.	132.6	9.7	1.9
1228.0	2.69	245.6	13.43	.	132.6	9.3	1.9
942.4	2.81	188.5	14.03	.	105.4	8.9	1.8
907.0	3.28	181.4	16.39	.	101.4	8.9	1.8
56.7	3.60	11.3	18.00	.	5.4	10.5	2.1
56.7	4.15	11.3	20.74	.	5.4	10.5	2.1

Table 9Ji. Demand for irrigation water on presently irrigated land (Region 10 - Lower Colorado).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
131.2	.70	65.6	1.40	20.9	.	6.3	3.1
128.0	.94	64.0	1.87	20.4	.	6.3	3.1
127.4	1.33	63.7	3.24	20.4	.	6.2	3.1
126.9	3.44	63.5	6.87	20.3	.	6.3	3.1
126.1	3.82	63.0	7.64	20.3	.	6.2	3.1
120.7	4.51	60.4	9.02	20.3	.	5.9	3.0
119.9	5.15	60.0	10.31	20.3	.	5.9	3.0
116.6	5.36	58.3	10.71	19.4	.	6.0	3.0
115.3	5.72	57.7	11.44	19.4	.	5.9	3.0
93.1	5.82	46.5	11.63	15.1	.	6.2	3.1
79.5	7.42	39.7	14.83	15.1	.	5.3	2.6
75.5	9.40	37.7	18.79	15.1	.	5.0	2.5
19.0	9.60	9.5	19.19	4.2	.	4.5	2.3
16.6	12.91	8.3	25.81	3.2	.	5.2	2.6

Table 9Jii. Demand for irrigation water on new land where development is not constrained to develop poor land with good land (Region 10 - Lower Colorado).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
807.6	.08	403.8	.16	.	148.8	5.4	2.7
807.6	.94	403.8	1.87	.	148.8	5.4	2.7
807.6	3.23	403.8	6.46	.	148.8	5.4	2.7
537.8	3.44	268.9	6.87	.	89.4	6.0	3.0
521.1	3.54	260.5	7.07	.	89.4	5.8	2.9
514.6	3.82	257.3	7.64	.	88.4	5.8	2.9
461.0	4.14	230.5	8.27	.	88.4	5.2	2.6
238.2	5.36	119.1	10.71	.	45.4	5.2	2.6
213.3	5.82	106.6	11.63	.	45.4	4.7	2.3
190.8	6.58	95.4	13.15	.	45.4	4.2	2.1
143.4	7.32	71.7	14.64	.	25.8	5.6	2.8
141.3	7.42	70.7	14.83	.	25.4	5.6	2.8
131.6	7.99	65.8	15.98	.	25.4	5.2	2.6
40.4	11.06	20.2	22.12	.	7.8	5.2	2.6
39.4	11.73	19.7	23.46	.	7.6	5.2	2.6

Table 9Jiii. Demand for irrigation water on new land where development is constrained to develop poor land with good land (Region 10 - Lower Colorado).

Water Diverted		Water Consumed		Acres Irrigated		Acre Feet Per Acre	
Amount	Price	Amount	Price	Old Land	New Land	Div-erted	Con-sumed
Thousand Acre-Feet	Dollars	Thousand Acre-Feet	Dollars	Thousand Acres	Thousand Acres	Acre Feet	Acre Feet
1318.6	.92	659.3	1.84	.	244.1	5.4	2.7
1266.8	2.09	633.4	4.17	.	244.1	5.2	2.6
663.6	2.29	331.8	4.58	.	111.3	6.0	3.0
640.9	2.93	320.5	5.87	.	111.3	5.8	2.9
627.2	3.16	313.6	6.32	.	108.9	5.8	2.9
627.0	3.26	313.5	6.51	.	108.8	5.8	2.9
626.6	3.49	313.3	6.99	.	108.8	5.8	2.9
624.5	3.54	312.3	7.07	.	108.4	5.8	2.9

APPENDIX C

Table 10. Within region supply function for water on presently irrigated land in thousands of acre-feet--Utah

Region	1965		1980		2000	
	Price	Quantity	Price	Quantity	Price	Quantity
1	.75	86	.75	90	.75	97
	1.00	124	1.00	120	1.00	112.5
			1.25	121	1.25	115.5
			5.15	122	5.15	119
2	.68	275	.63	470	.63	1015
	.75	1015	.68	1015	4.63	1039
	1.75	1033	4.68	1183	28.49	1214
	4.68	1190	28.49	1312	38.46	1261
	4.83	1239	28.75	1357		
	13.21	1291	38.46	1405		
	28.46	1463				
	38.02	1515				
3	.75	611	.52	180	.52	611
	2.00	643	.68	611	10.23	680
	5.18	665	4.93	621	14.17	728
	5.42	762	5.41	698	14.33	1020
	14.33	1296	14.17	728	93.22	1042
	93.22	1318	14.33	1175		
			93.22	1200		
4	.75	715	.68	715	.53	71
	2.75	799	5.18	731	.68	715
	5.19	849	5.54	844	5.18	731
	5.72	1131	5.72	963		
5	.75	655	.75	660	.75	666
	1.10	786	1.10	777	1.10	764
	1.28	875	1.28	866	1.28	857
	2.80	890	2.80	885	2.80	880
	9.89	923	9.89	916	9.89	908
6	.95	34	.95	36	.95	26
	1.15	47	1.47	161	1.47	156.5
	1.47	165				
7	.75	792	.75	792	.75	792
	5.25	1045	5.25	1000	5.25	950
	35.92	1217	35.92	1176	35.92	1122
	70.68	1382	70.68	1341	70.68	1285

Table 10. Continued

Region	1965		1980		2000	
	Price	Quantity	Price	Quantity	Price	Quantity
8	.75	303	.75	303	.75	303
	5.25	534	5.25	525	5.25	513
	25.91	634	25.91	626	25.91	613
9	.75	150	.75	150	.75	150
	5.25	293	5.25	259	5.25	214
	25.95	370	25.95	337	25.95	292
	33.91	381	33.91	346.5	33.91	302
10	.75	68	.75	68	.75	68
	5.25	181	5.25	179	5.25	177
	29.38	217.5	29.38	216	29.38	213
	39.12	252.5	39.12	250	39.12	247

Table 11. Projected supply and demand intersection points for water on presently irrigated land in thousands of acre-feet, Utah

Region	1965		1980		2000	
	Price	Quantity	Price	Quantity	Price	Quantity
1	5.24	124	5.24	122	5.24	119
2	.75	945.5	.68	945.5	.63	945.5
3	1.54	611	1.54	611	1.54	611
4	2.75	719.0	2.83	715	2.83	715
5	7.32	890	7.32	885	7.32	880
6	8.36	165	8.79	161	9.21	156.5
7	1.73	792	1.73	792	1.73	792
8	3.90	303	3.90	303	3.90	303
9	1.73	150	1.73	150	1.73	150
10	5.25	116.6	5.25	116.6	5.25	116.6

Table 12. Residual supply curves in thousands of acre-feet

Region	1965 Price	1965 Quantity	1980 Price	1980 Quantity	2000 Price	2000 Quantity
1	---	---	---	---	---	---
2	.75	69.5	.75	69.5	.75	69.5
	1.75	87.5	4.68	237.5	4.63	93.5
	4.68	244.5	28.49	366.5	28.49	268.5
	4.83	293.5	28.75	411.5	38.46	315.5
	13.21	345.5	38.46	459.5		
	28.46	517.5				
	38.02	569.5				
3	2.00	33.0	4.93	11.0	10.23	70.0
	5.18	55.0	5.41	88.0	14.17	118.0
	5.42	152.0	14.17	118.0	14.33	410.0
	14.33	686.0	14.33	565.0	93.22	432.0
	93.22	708.0	93.22	590.0		
4	2.75	80.0	5.18	16.0	5.18	16.0
	5.19	130.0	5.54	129.0		
	5.72	412.0	5.72	248.0		
5	9.89	32.0	9.89	30.0	9.89	27.0
6	---	---	---	---	---	---
7	5.25	253.0	5.25	208.0	5.25	158.0
	35.92	425.0	35.92	384.0	35.92	330.0
	70.68	590.0	70.68	549.0	70.68	493.0
8	5.25	231.0	5.25	222.0	5.25	210.0
	25.91	331.0	25.91	323.0	25.91	310.0
9	5.25	143.0	5.25	109.0	5.25	64.0
	25.95	220.0	25.95	187.0	25.95	142.0
	33.91	231.0	33.91	196.5	33.91	152.0
10	5.25	64.4	5.25	62.4	5.25	60.4
	29.38	100.9	29.38	99.4	29.38	96.4
	39.12	135.9	39.12	133.4	39.12	130.4

APPENDIX D

Table 13. Cost components of transporting water among hydrologic subregions within Utah (Includes diversions and storage, transport, and new distribution costs)

To Subregion \ From Subregion	2	3	4	5	7			10
					Bonneville Unit	Ute Indian Unit	Sevier Unit	
1	$ 14.20							
3	13.95					$ 20.20		
4		$ 25.55			$ 28.55	31.55	$ 29.55	
5			$ 22.75		27.75	30.75	21.75	
6				$ 17.10				$ 22.80

Source: King, 1972, Table 9.

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